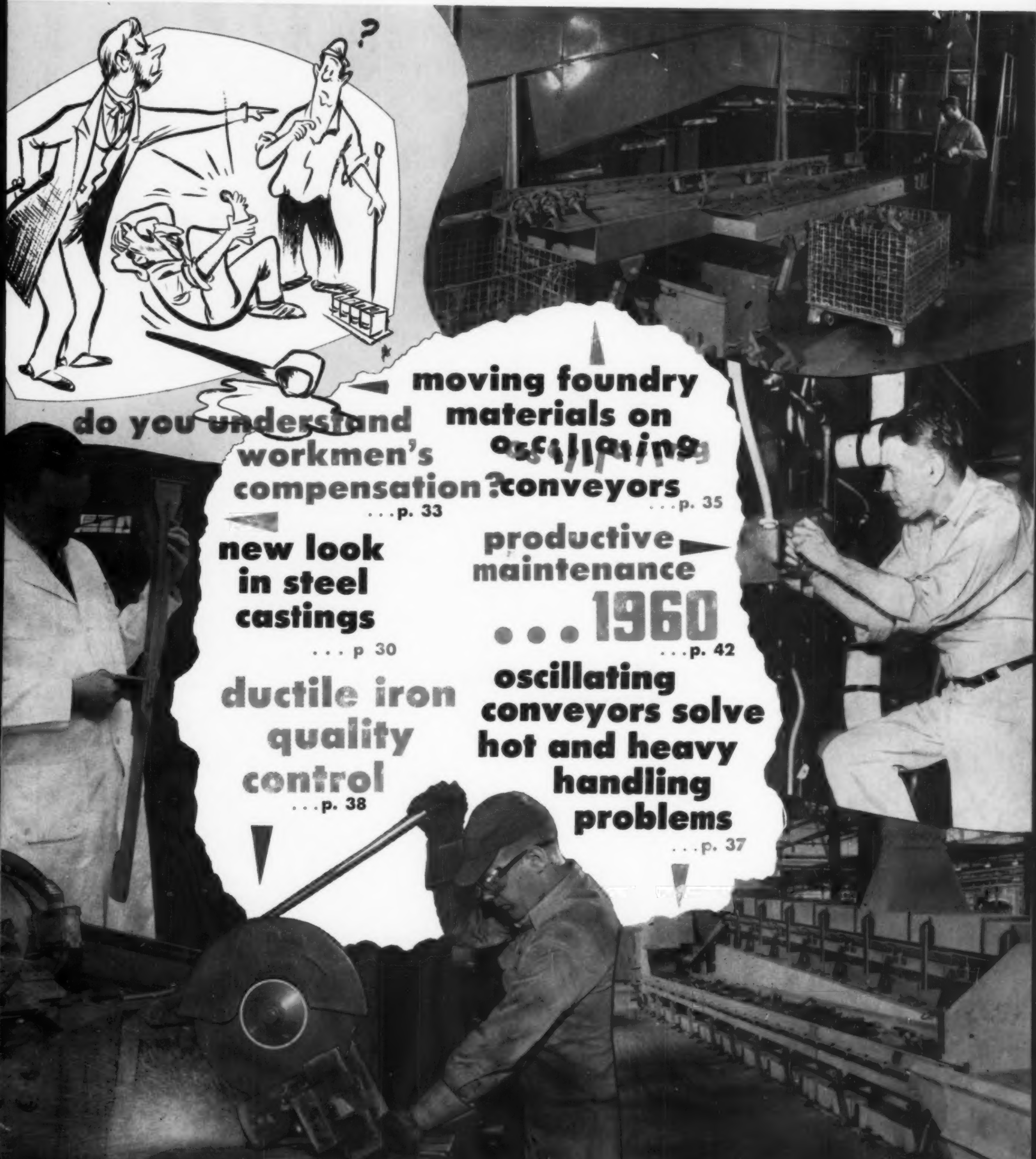
AFS

OCTOBER, 1959

modern castings



do you understand workmen's compensation? ...p. 33

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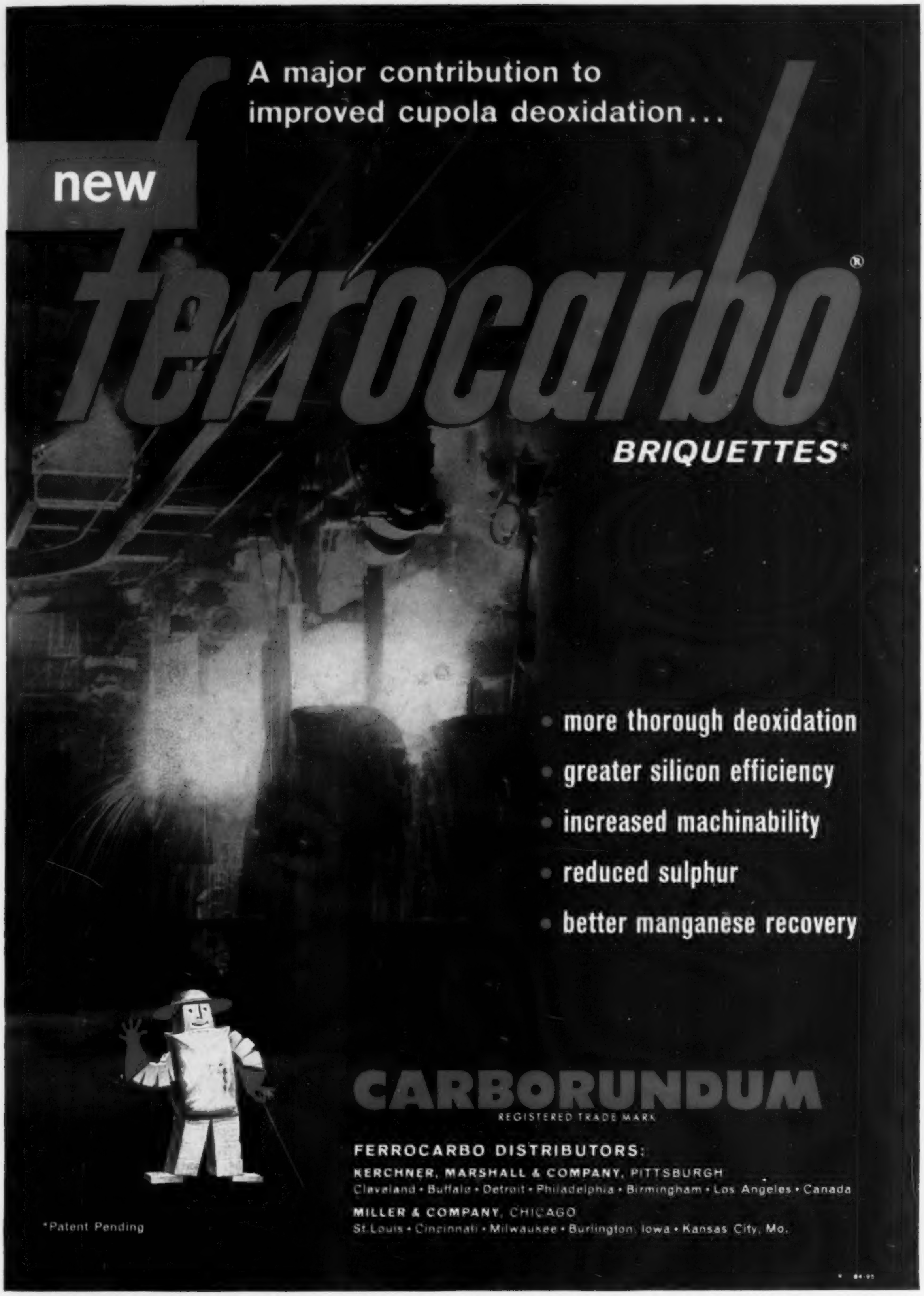
oscillating conveyors solve hot and heavy handling problems ...p. 37



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*Patent Pending

october, 1959
vol. 36, no. 4

modern castings

the technical magazine of the metalcasting industry

features

1959 Castings Congress Papers

featurettes

departments

future meetings and exhibits

OCTOBER

Sept. 28-Oct. 1 . . Association of Iron and Steel Engineers, *Annual Convention*. Sherman Hotel, Chicago.

Sept. 28-Oct. 1 . . American Welding Society, *Fall Meeting*. Hotel Sheraton-Cadillac, Detroit.

Sept. 29-Oct. 1 . . National Association of Corrosion Engineers, *Western Regional Conference*. Bakersfield Inn, Bakersfield, Calif.

1-2 . . AFS *Empire State Regional Foundry Conference*. Drumlins Country Club, Syracuse, N. Y.

2-3 . . AFS *Northwest Regional Foundry Conference*. Benjamin Franklin Hotel, Seattle.

3-10 . . International Committee of Foundry Technical Associations, *International Foundry Congress*. Madrid, Spain.

5-7 . . Material Handling Institute, *Joint Industry Fall Meeting*. Lake Placid Club, Essex County, N. Y.

7-9 . . Gray Iron Founders' Society, *Annual Meeting*. Fairmont Hotel, San Francisco.

8-9 . . AFS *Michigan Regional Foundry Conference*. Pantlind Hotel, Grand Rapids, Mich.

8-10 . . American Society of Tool Engineers, *Semi-annual Meeting*. St. Louis.

10-13 . . Conveyor Equipment Manufacturers Association, *Annual Meeting*. Grand Hotel, Point Clear, Ala.

11-16 . . American Society for Testing Materials, *Pacific Area National Meeting & Exhibit*. Sheraton Palace Hotel, San Francisco.

12-17 . . National Industrial Sand Association, *Semi-annual Meeting*. The Greenbrier, White Sulphur Springs, W. Va.

15-17 . . Foundry Equipment Manufacturers Assn., *Annual Meeting*. The Greenbrier, White Sulphur Springs, W. Va.

16-17 . . AFS *New England Regional Foundry Conference*. Massachusetts Institute of Technology, Cambridge, Mass.

19-20 . . Magnesium Association, *Annual Convention*. Hotel Roosevelt, New York.

19-23 . . National Management Association, *Annual Meeting and National Conference*. Statler-Hilton Hotel, Detroit.

19-23 . . National Safety Council, *National Safety Congress & Exposition*. Conrad Hilton Hotel, Chicago.

21 . . Cast Bronze Bearing Institute, *Annual Meeting*. Bedford Springs Hotel, Bedford, Pa.

22-23 . . AFS *Ohio Regional Foundry Conference*. Deshler-Hilton Hotel, Columbus, Ohio.

22-24 . . Non-Ferrous Founders' Society, *Annual Meeting*. Bedford Springs Hotel, Bedford, Pa.

29-30 . . AFS *Purdue Metals Casting Conference*. Purdue University, West Lafayette, Ind.

NOVEMBER

3-4 . . Investment Casting Institute, *Annual Meeting*. LaSalle Hotel, Chicago.

5-6 . . National Foundry Association, *Annual Meeting*. Roosevelt Hotel, New York.

9-11 . . Steel Founders' Society of America, *Technical & Operating Conference*. Carter Hotel, Cleveland.

20-21 . . AFS *East Coast Regional Foundry Conference*. Statler-Hilton Hotel, New York.

DECEMBER

2-4 . . Metallurgical Society of American Institute of Mining, Metallurgical & Petroleum Engineers, *Electric Furnace Conference*. Cleveland Hotel, Cleveland.

13-16 . . Material Handling Institute, *Annual Meeting*. Savoy-Hilton Hotel, New York.

2-4 . . National Association of Manufacturers, *Annual Meeting*. Waldorf-Astoria Hotel, New York.

1960

MAY

9-13 . . AFS 64*th Annual Castings Congress & Foundry Show*. Convention Hall, Philadelphia.

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"When it comes to smooth finish and tight tolerances . . .

we're our own TOUGHEST CUSTOMER"

"For instance, take these cable drums for our Hevi-Duty cranes; they go from cleaning right into assembly—no machining at all, except the bearing surfaces. Means we need rigid control of molding, facing and core sand mixes. Here's where we count on ADM. Their GREEN BOND Bentonite builds up the green strength of our system sand—prevents mold wall movement—keeps dimensions on the button. CROWN HILL sea coal in our facing sand gives the peel I need for an extra-smooth finish. I hear they more than doubled core production with LIN-O-SET, too,—that's ADM's air setting core binder. I play safe with these ADM products, especially where a tough customer like Koehring is calling the shots."

Write ADM for latest information on GREEN BOND Bentonite, CROWN HILL Sea Coal, and LIN-O-SET Air-setting Binder.

Success story reported by Ken Armstrong, Molding Foreman, Koehring Company, Foundry Division, Milwaukee

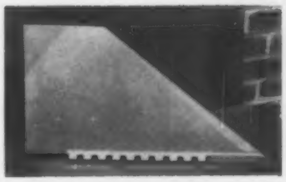
DETAILED INFORMATION ON ALL ADM PRODUCTS CAN BE FOUND IN THE AFS BUYERS' GUIDE.

Circle No. 146, Page 155-156

the editor's report

by Jack Schaum

Another foundry heard from . . . in answer to our request to hear from foundries pushing tensile barriers toward new horizons. The H & S Metal Products Co., Los Angeles, Calif., makes the Bullpup Missile wing casting, shown here, with guaranteed mechanical properties in the casting of 45,000 psi ultimate tensile strength, 38,000 psi yield and 3 per cent ductility. Made from high purity 356 aluminum alloy the part is produced as a close tolerance centrifugal permanent mold casting. Congratulations Mr. W. C. Smith, president of H & S, for demonstrating how castings can be used to maximum effectiveness. And let's hear from more of you aggressive foundrymen.



Dee Foundry, Houston, Texas, is pouring 3400 lb of Al bronze into a single mold hardened by CO_2. Molds made in morning are poured in afternoon. Cope and drag patterns are mounted on plywood. The two pieces of plywood are attached to a spacer which permits CO_2 gas to be introduced simultaneously to cope and drag after ramming. Vents drilled in pattern allow gas to diffuse through pattern surface out into sand.

Green sand as-cast finish . . . has come a long way under the beneficial pressure of competition from other molding mediums. Now-a-days it's not uncommon to have green sand castings so smooth that they come out of the blast cleaning operations rougher than they went in.

Big revolution coming in die casting . . . from Europe where they are using sonic vibration during pouring. Casting pressure can be reduced to 25 psi; permits slower pouring through bigger gates at lower temperatures. Eliminates porosity and entrapped air. Source of vibration is transducer which can transfer energy to optimum locations on die and through cores. Installations are said to be cheaper than vacuum with many of the same benefits.

As little as 2 per cent . . . sand mixed into your metal shot used for casting cleaning can cut life of impellors from 2000 hours to as little as 50 hours. Foundrymen should be alert to proper adjustment of shot cleaning equipment so separator removes this residual silica from the shot.

What next! Steel felt is the latest addition to new engineering materials. Armour Research Foundation makes a slurry of steel wool fibers and shapes it by pouring it over a porous mold. After sintering for strength the pores are filled by pouring molten magnesium over the steel felt. The result is a new conglomeration called steel felt containing 5 to 50 per cent steel and balance magnesium. The felt can be shaped to any configuration, has good impact and tensile properties with a superior strength to weight ratio.

Outboard motors in the foundry . . . ever see one being used for agitating the water in a quench tank? The American Brake Shoe Co. aluminum foundry at Mahwah, N.J., improves water quench efficiency in the heat treat department with a 7-1/2-hp outboard. Does a real good job too. Wonder who uses it on week-ends for improved fishing efficiency?

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VAnderbilt 4-0181

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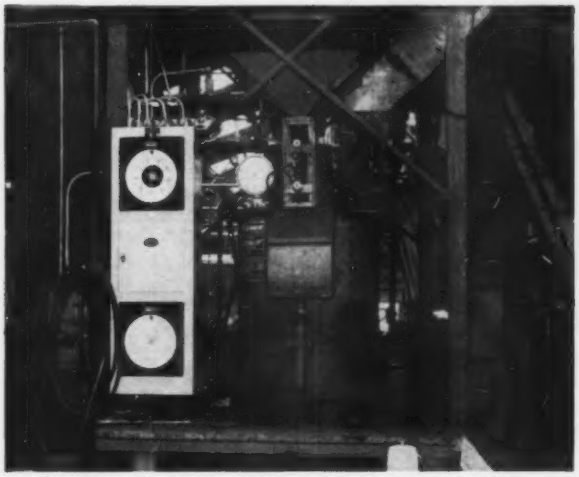
Circle No. 148, Page 155-156

GLAUBER VALVE CO.—A small, high production brass shop—needed a muller that would provide a high capacity of sand mulled to exacting specification in a completely automatic set-up. The Speedmullor with Mulltrolmatic was the answer . . . it provided the essential features . . . productivity, compactness, thoroughness *and economy.*



WORTH MFG. CO.—Small Texas aluminum production shop chose a Speedmullor for the same reasons. Investigation proved to management that only the Speedmullor provided the capacity, compact size, efficiency and economy needed. This budget-minded foundry couldn't afford to compromise on "second-best."

WAUSEON FOUNDRY—Small Ohio gray iron shop competing with the best-equipped foundries in the country—chose Speedmullor, too. Again the reasons were the same . . . high production, superior efficiency *and economy.* This cost-conscious foundry couldn't afford a "wrong choice."

ONLY THE SPEEDMULLOR IS BUILT FOR BUDGETS

BEARDSLEY & PIPER

Div. Pettibone Mulliken Corp., 2424 N. Cicero Ave.
Chicago 39, Ill.

Circle No. 149, Page 155-156

Russian foundry practice . . .

is quite comparable to current American technology and well worth watching for new ideas. Statements and claims in these items about USSR metalcasting developments appeared in abstracts prepared by the Office of Technical Services, U. S. Department of Commerce, Washington, D. C.

■ Radiator sections are being made with a slush-casting technique. Coreless mold is attached on top of crucible of molten iron and whole assembly is rotated 180 degrees. After a predetermined interval of time the unit is rotated back to original position letting remaining molten metal run back into crucible. Russians claim system suited to many hollow shaped castings and produces higher density metal than obtained when using oil sand cores.

■ Iron castings are being made in anodized aluminum molds. Molds do not melt, corrode or crack.

■ Graphite molds are being substituted for sand molds at a savings of 10 per cent on cost of a ton of castings. As many as 350 castings can be made from one mold.

STATEMENT OF OWNERSHIP

Statement required by the act of August 24, 1912, as amended by the Acts of March 3, 1933, and July 2, 1946 (Title 39, United States Code, Section 233) showing the ownership, management and circulation of MODERN CASTINGS, published monthly at Pontiac, Ill., for October 1, 1959. 1—The names and addresses of the publisher, editor, managing editor, and business manager are: Publisher, American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill.; Editor, Jack H. Schaum, Golf & Wolf Roads, Des Plaines, Ill.; Business Manager, Wm. W. Maloney, Golf & Wolf Roads, Des Plaines, Ill. 2—The owner is: American Foundrymen's Society, Golf & Wolf Roads, Des Plaines, Ill. Organized not for profit, without stock. Principal officers: President, Charles E. Nelson, Magnesium Div., Dow Chemical Co., Midland, Mich.; Vice-President, Norman J. Dunbeck, Industrial Minerals Div., International Minerals & Chemical Corp., Skokie, Ill. General Manager, Wm. W. Maloney, American Foundrymen's Society, Golf & Wolf Roads, Des Plaines, Ill.; Secretary, Ashley B. Sinnett, American Foundrymen's Society, Golf & Wolf Roads, Des Plaines, Ill.; Treasurer, Edward R. May, American Foundrymen's Society, Golf & Wolf Roads, Des Plaines, Ill. 3—The known bondholders, mortgages, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are none. 4—Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner. Jack H. Schaum, Editor. Sworn to and subscribed before me this 44th day of September, 1959 (Seal). E. R. May notary public. (My commission expires March 14, 1960.)

Circle No. 151, Page 155-156

Build an idea-file for improvement and profit. The post-free cards on the last page will bring more information . . .

for the asking

Alloy analysis chart . . . features sliding rule giving you instant analysis of over 125 super alloys, cobalt alloys and nickel chrome alloys. Security Alloys Co.
For Your Copy, Circle No. 61, Page 155-156

Cherry flasks . . . presented in data sheet which explains completely new operation. Adams Co.
For Your Copy, Circle No. 62, Page 155-156

Precision temperature . . . measuring instruments operating by optical, micro-optical, radiation, immersion, surface and indicating methods. Send for catalog. Pyrometer Instrument Co.
For Your Copy, Circle No. 63, Page 155-156

Pocket size booklet . . . titled, "How to Select and Maintain Foundry Flasks," is available to you free.
For Your Copy, Circle No. 64, Page 155-156

Belt unit . . . for grinding and polishing of castings described in bulletin No. 104 which includes simple and ingenious uses for this equipment. Grinding and Polishing Machinery Corp.
For Your Copy, Circle No. 65, Page 155-156

The small foundry . . . finds some interesting uses for this company's equipment. Request the September, 1959 issue of their publication. Beardsley & Piper Div., Pettibone Mulliken Corp.
For Your Copy, Circle No. 66, Page 155-156

Core binders . . . of liquid Phenol-Formaldehyde to be used in place of core oils where baking time is at a premium and high tensile strengths and hardnesses are required. Request bulletin F-1-R. Reichhold Chemicals, Inc.
For Your Copy, Circle No. 67, Page 155-156

Foundry coke . . . folder describes manufacturing process; lists grade sizes. DeBardeleben Coal Corp.
For Your Copy, Circle No. 68, Page 155-156

CO_2 process . . . handbook illustrates equipment and describes process, 46 pp. Carver Foundry Products Co.
For Your Copy, Circle No. 69, Page 155-156

Refining and desulphurizing . . . cupola iron described in brochure which outlines specifications and applications of cupola flux. Olin Mathieson Chemical Corp.
For Your Copy, Circle No. 70, Page 155-156

Electric-furnace smelting . . . and subsequent refining of almost any type of iron ore described in 16-p brochure. Presents layout drawing of typical plant, and estimated capital and operating costs. Koppers Co.
For Your Copy, Circle No. 71, Page 155-156

Management aids . . . published by the United States Government offer valuable assistance to those in responsible positions in small business. Following is a list of bulletins available when you circle the appropriate number on the Reader Service card, last page.

Know Your Patenting Procedures
For Your Copy, Circle No. 73, Page 155-156

Redesigning Products for Better Marketability
For Your Copy, Circle No. 74, Page 155-156

Making a Marketing Survey
For Your Copy, Circle No. 75, Page 155-156

Turn Customer Complaints Into Profits
For Your Copy, Circle No. 76, Page 155-156

Methods Engineering for the Small Plant
For Your Copy, Circle No. 77, Page 155-156

Developing Foremen in Small Plants
For Your Copy, Circle No. 78, Page 155-156

How Good Records Aid Income Tax Reporting
For Your Copy, Circle No. 79, Page 155-156

Pinholes or inclusions . . . is the title of newsletter which discusses inspection, causes, inclusions, improperly cleaned ladles and other factors causing these faults. American Colloid Co.
For Your Copy, Circle No. 80, Page 155-156

Welders' vest-pocket guide . . . describes and illustrates in 60 pp four essentials of proper welding procedures, types of joints and welding positions. Hobart Bros. Co.
For Your Copy, Circle No. 81, Page 155-156

Radiography . . . in modern industry handbook, 140 pp, well illustrated, for engineer or student. X-Ray Div., Eastman Kodak Co.
For Your Copy, Circle No. 82, Page 155-156

Ductile iron . . . mechanical and physical properties listed in 28-p brochure. Industrial applications pointed out. International Nickel Co.
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Temperature conversion . . . chart, wallet-size, with easy-to-read tables of Fahrenheit and Centigrade temperature equivalents. Moeller Instrument Co.
For Your Copy, Circle No. 84, Page 155-156

Microscopic photography . . . data book of the elementary photomicrographic technique available in a revised edition. Eastman Kodak Co.
For Your Copy, Circle No. 85, Page 155-156

Inoculants . . . for cast and ductile iron described in booklets which use pictures, graphs and tables to show advantages. Electro Metallurgical Co., Div. Union Carbide Corp.
For Your Copy, Circle No. 86, Page 155-156

Birth of gray iron castings . . . related in technical, colorful, 20-p book. Pittsburgh Coke & Chemical Co.
For Your Copy, Circle No. 87, Page 155-156

Machining gray and nodular iron . . . 22-p booklet covers machining properties of cast iron. Hamilton Foundry & Machine Co.
For Your Copy, Circle No. 88, Page 155-156

Technical data . . . catalog free. Revised listing of pocket-size books covering every field of engineering. Lefax Publishers.
For Your Copy, Circle No. 89, Page 155-156

Carbon sand . . . a new molding material composed of particles of hard carbon is described and compared with other molding sands. J. S. McCormick Co.
For Your Copy, Circle No. 90, Page 155-156

Shell casting . . . featured in monthly publication. Cooper Alloy Corp.
For Your Copy, Circle No. 91, Page 155-156

Manufactured graphite . . . technical data offered in handbook. National Carbon Co., Div. Union Carbide Corp.
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Foundry practice . . . bulletin includes four technical articles dealing with: aluminum rotor castings, copper-tin alloys, pressure and exothermic feeding of iron castings and heat treatment. Foundry Services, Inc.
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Molybdenum . . . its role in steel castings, thoroughly discussed in 36-p booklet prepared at Case Institute of Technology for Steel Founders Society. Climax Molybdenum Co.
For Your Copy, Circle No. 94, Page 155-156

Wall chart . . . lists decimal equivalents of fractions of an inch—1/64 to 1 in. Use the Reader Service card, last page, for your free chart. Ohio Seamless Tube Div., Copperweld Steel Co.
Centrifugal casting . . . process fully explained and illustrated in 8-p booklet. Centrifugal Casting Co.
For Your Copy, Circle No. 95, Page 155-156

Technical translations . . . of Russian and other technical material are included in new government publication. For more information about this service, use circle number below. Office of Techni-

Continued on page 17

for the asking

Continued from page 14

cal Services, United States Department of Commerce.
For Your Copy, Circle No. 96, Page 155-156

Iron and steel scrap . . . fact sheet in folder form answers many questions about scrap. Institute of Scrap Iron & Steel Inc., Committee on Bankability.
For Your Copy, Circle No. 97, Page 155-156

Japanese foundry equipment . . . well illustrated and described in catalog. Written in English. Kubota Seisakusho, Ltd.
For Your Copy, Circle No. 98, Page 155-156

Machining manual . . . 22-pp, contains guide for machine feeds and speed, includes quantity-weight slide rule calculator, and other basic information. Kaiser Aluminum & Chemical Sales, Inc.
For Your Copy, Circle No. 99, Page 155-156

Shell molding . . . with forsterite grains described in 4-p brochure. Harbison-Walker Refractories Co.
For Your Copy, Circle No. 100, Page 155-156

Steelmaking . . . through use of oxygen in electric furnaces is subject of information report discussing advantages of oxygen and listing techniques and equipment. National Cylinder Gas, Div. Chemetron Corp.
For Your Copy, Circle No. 101, Page 155-156

Shell molding . . . problems answered in brochure. Answers such questions as, "How to avoid casting fins in shell molding." General Electric Co.
For Your Copy, Circle No. 102, Page 155-156

Microstructure . . . of gray iron castings illustrated in 12-p booklet showing micrographs of castings with from 31,500 to 63,000 psi. To obtain, use circle number. Herbert A. Reese & Associates.
For Your Copy, Circle No. 103, Page 155-156

Chaplet selection chart . . . reportedly demonstrates quick and easy methods of determining size and number of chaplets required to support cores to obtain dimensionally accurate wall thicknesses. Fanner Mfg. Co.
For Your Copy, Circle No. 104, Page 155-156

Pouring practice . . . for bottom-pour ladle systems discussed in well-illustrated brochure. Vesuvius Crucible Co.
For Your Copy, Circle No. 105, Page 155-156

Training courses . . . pertinent to every type of metalcasting work are offered by the AFS Training and Research Institute. For free brochure covering all courses offered, circle number below on Reader Service card, last page. American Foundrymen's Society.
For Your Copy, Circle No. 106, Page 155-156

Wood and metal pattern . . . development and production fully described in 12-p booklet. Motor Patterns Co.
For Your Copy, Circle No. 107, Page 155-156

Pearlitic malleable handbook . . . 76 pp, serves as ready reference on latest information and data. A copy is yours if you are a design engineer or can use this engineering data in your work. Malleable Research and Development Foundation.
For Your Copy, Circle No. 108, Page 155-156

Wall chart . . . giving designations and specifications for non-ferrous alloys. To get yours, circle number below on Reader Service card, last page of this issue. Non-Ferrous Founders' Society.
For Your Copy, Circle No. 109, Page 155-156

Core processes . . . reprint, six pp, discusses four major core making processes with a comparison of advantages and disadvantages of each. Archer-Daniels-Midland Co.
For Your Copy, Circle No. 110, Page 155-156

don't gamble
on the materials you use; learn all about all products by reading the data available by circling numbers on card, last page.

New abrasive shot . . . is claimed to reduce blast cleaning costs by offering steel shot characteristics at malleable shot prices. Data sheet 1M 157 SP. Metal Blast, Inc.
For Your Copy, Circle No. 111, Page 155-156

Heavy-duty fork trucks . . . pictured and described in new booklet. Feature engineering for rugged stop-and-go driving. Towmotor Corp.
For Your Copy, Circle No. 112, Page 155-156

Cleaning industrial floors . . . is subject of booklet which also covers care and maintenance. Oakite Products, Inc.
For Your Copy, Circle No. 113, Page 155-156

Aluminum welding techniques . . . using gas-shielded metal-arc and tungsten-inert-gas processes detailed in 120-page book, yours when you circle number below on Reader Service card, last page. Air Reduction Sales Co.
For Your Copy, Circle No. 114, Page 155-156

Lifting and dumping . . . units for handling drums, boxes, bags and inplant trucks covered in folder. Cesco Dumpers.
For Your Copy, Circle No. 115, Page 155-156

Business ethics . . . and examples of "shady" and "shadow" dealings offered in government bulletin No. 44. Small Business Administration.
For Your Copy, Circle No. 116, Page 155-156

Where to buy . . . gray and ductile iron castings? Use the Reader Service card, last page, for this buyers guide and directory of members. Gray Iron Founders' Society, Inc.
For Your Copy, Circle No. 117, Page 155-156

Ultrasonic machining . . . of hard, brittle materials previously considered unmachinable is said to be accomplished by method assuring no change in the

Continued on page 20

A REPORT TO FOUNDRIES

FROM TOM BARLOW

Clays with character

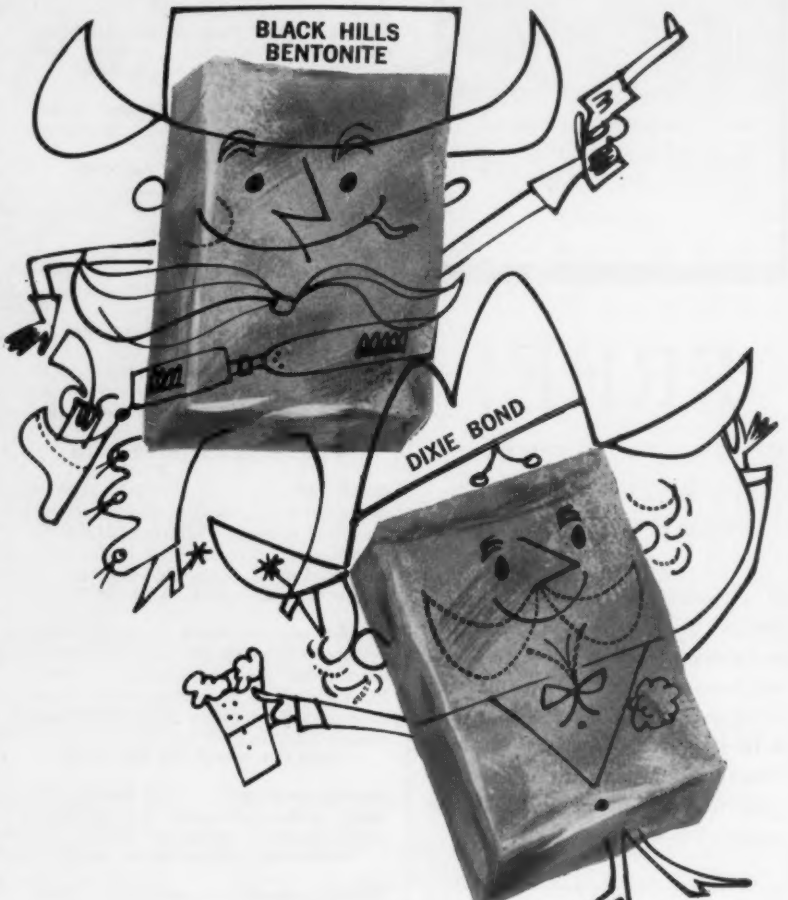
You might say that clays are like people — each one has a *character* like no other. Never let anyone tell you that the only difference is the hole in the ground they came from.

Take Black Hills Bentonite. It's an extremely strong, uniform and dependable bentonite of the Wyoming type. Here is a clay with lusty personality and a character that has won it a wide circle of friends. The reasons are plain enough: (1) highest dry strength combined with high resilience . . . (2) highest dry strength combined with highest hot strength . . . (3) highest dry strength combined with highest permeability.

And consider the need for resilience in sand — "bounce to the ounce." Of course, we're talking about a sand's degree of *yield* or *give* before breaking (called deformation). When you multiply the deformation value by the green strength, and a factor, the result is the sand value we call resilience. It is the *amount* of springiness or toughness possessed by a sand, and sands lacking this property are said to be brittle.

In this characteristic, Black Hills Bentonite excels over any other type of bond clay. It results in a sand that is *tough*. Less trouble is experienced with difficult lifts, and there is less breakage of corners and edge molds.

Now take green strength. Black Hills Bentonite yields very high green strength (although it is excelled in this respect by Dixie Bond). When we use it as specified, the result is high permeability, with a minimum amount of tempering water, and with less material to handle and less dead clay eventually left in heaps or to be removed.



And there's still more to this character analysis.

Dry strength: Black Hills Bentonite gives higher dry strength than any other type bond clay. This is insurance against cuts and washes, particularly in steel foundry practice.

For green sand or medium weight dry sand work, Black Hills Bentonite provides the highest dry strength per unit of clay used. (In making very heavy castings, however, fire clay binders such as Revivo Bond are usually selected because of the combination of high sintering point with adequate dry strength. But before our sermon degenerates into some kind of "Revivo meeting," let's move along to Dixie Bond, our second character study.)

Circle No. 155, Page 155-156

for the asking

Continued from page 17

chemical, metallurgical or physical properties during or after machining. Ask for bulletin UG559. Precision Glass Products Co.

For Your Copy, Circle No. 118, Page 155-156

Precision forming process . . . detailed in new literature featuring eight case studies of different parts made by this process. Casting Engineers, Inc.

For Your Copy, Circle No. 119, Page 155-156

Vacuum induction furnace . . . discussed in data sheet. Features compact construction and floor level operation; 12-lb model. NRC Equipment Corp.

For Your Copy, Circle No. 120, Page 155-156

Controlling electric power . . . through new concept utilizing furnace demand computer which determines electric power demand use. Form No. 558. Pennsylvania Transformer Div., McGraw-Edison Co.

For Your Copy, Circle No. 121, Page 155-156

Permanent plate magnets . . . discussed in bulletin No. 1074 giving data for selection of proper magnet for chutes, ducts, conveyors, etc. Stearns Magnetic Products.

For Your Copy, Circle No. 122, Page 155-156

New nickel-base alloy . . . resists molten fluoride salts. Reportedly is useful in normally corrosive environments involving fluorides at high temperatures; alloy will cast in sand, shell or investment processes. Send for 12-p booklet. Haynes Stellite Co. Div., Union Carbide Corp.

For Your Copy, Circle No. 123, Page 155-156

Precision mechanical finishing . . . catalog outlines processes such as grinding, deburring, descaling and polishing. Roto-Finish Co.

For Your Copy, Circle No. 124, Page 155-156

Heavy duty air compressors . . . for industrial use described in bulletin A-73. Joy Mfg. Co.

For Your Copy, Circle No. 125, Page 155-156

Ferrocolumbium . . . in steel and high-temperature alloys discussed in new folder. Union Carbide Metals Co.

For Your Copy, Circle No. 126, Page 155-156

training films

■ The following list of motion pictures and film strips will prove useful in educating your personnel to better perform their jobs. Circle the appropriate number on the Reader Service Card, last page, for complete information regarding these films. Items indicate whether films are available free of charge, by rental or by purchase only.

Power shift, shows ease of operating fork-lift trucks with power shift. Color, sound, 16 mm, 5 min., free. Allis-Chalmers.

For Your Copy, Circle No. 127, Page 155-156

Refining Copper from the Sudbury Nickel Ores, designed primarily for audi-

Continued on page 22

for the asking

Continued from page 20

ences with some technical background. Depicts refining and producing high purity cooper from raw material received from the smelter. Color, sound, 16 mm, 39 min. free. International Nickel Co.
For Your Copy, Circle No. 128, Page 155-156

The Box Grab, a case study film with scenes showing operation of this attachment. Sound, black and white, 16 mm, 9 min., free. Hyster Co.
For Your Copy, Circle No. 129, Page 155-156

You Decide, is a film useful to everyone in supervisory capacities. Assumes viewer is member of board of directors, presents problem for decision, after allowing a minute for the viewer to decide what should be done, the film then shows what was actually decided by those concerned. Sound, color, 16 mm, 28 min. free. Ohio Oil Co./Modern Talking Picture Service, Inc.
For Your Copy, Circle No. 130, Page 155-156

Modern Basic Refractories, such as those made from magnesium oxide shown in film describing how they are produced and how they are used to line furnaces used in steel and copper production. Kaiser Chemicals Div., Kaiser Aluminum & Chemical Corp./Modern Talking Picture Service, Inc.
For Your Copy, Circle No. 131, Page 155-156

free reprints

■ **The following reprints of feature articles which appeared in MODERN CASTINGS are available to you free of charge. Use the Reader Service card, last page.**

Malleable iron . . . discussed in technical report dealing with magnetic properties of the alloy. American Foundrymen's Society.
For Your Copy, Circle No. 132, Page 155-156

Effect of scrap size . . . on the tapping temperature of a cupola discussed in technical reprint from MODERN CASTINGS. American Foundrymen's Society.
For Your Copy, Circle No. 133, Page 155-156

Copper in cast iron . . . reprint deals with theoretical considerations and experimental results of the effect of copper in cast iron. American Foundrymen's Society.
For Your Copy, Circle No. 134. Page 155-156

Buy, build or modernize . . . this was the question facing a foundry wishing to make the best decision for producing top quality castings. Read how they arrived at their decision in this MODERN CASTINGS reprint. American Foundrymen's Society.
For Your Copy, Circle No. 135, Page 155-156

Green sand quality control . . . discussed in article reprinted from MODERN CASTINGS and available to you free when you circle number below on the Reader Service card, last page. American Foundrymen's Society.
For Your Copy, Circle No. 136, Page 155-156

H. E. Henderson

Howard Voit

John R. Gorey

G. W. Johnson

let's get personal

Harvey E. Henderson . . . has been named technical director, Lynchburg Foundry Co., Lynchburg, Va. An employee of Lynchburg Foundry since 1947, Henderson has served as a metallurgist in various capacities, most recently as project engineer in the research department. He is vice-chairman of the AFS Gray Iron Division and the author of several technical papers on foundry practices and metallurgy.

Howard Voit . . . associated with Sterling National Industries since 1946 and branch manager of the New York office since 1951, has been named as sales and advertising manager at the firm's headquarters in Milwaukee.

Carl L. Graeber . . . personnel development consultant; **Ralph L. Lee,** retired secretary-treasurer, Grede Foundries, Inc., Milwaukee; **Frank X. Hohn,** formerly associated with Scullin Steel Steel Co., St. Louis; and **E. E. Henry,** specialist in non-ferrous shop operations are special service consultants with Westover Corp. & Associates, Milwaukee.

Spencer S. Philips . . . has been named assistant manager, iron foundry service, Ohio Ferro-Alloys Corp., Canton, Ohio. He was formerly technical director, Sibley Machine & Foundry Corp., South Bend, Ind.

Samuel S. Johnson . . . has been named assistant superintendent of foundries, Hamilton Foundry, Inc., Hamilton, Ohio. **John R. Puckett** is now customer service supervisor and **Donald P. McCaffrey** has been promoted to foundry section foreman.

Francis E. Smith . . . is now mid-west regional sales manager for the alloys and metals division of Tennessee Products & Chemical Corp. Smith is responsible for sales in areas including Pittsburgh, Detroit and St. Louis. District offices have been established in the two latter cities.

Murray T. Stewart . . . has joined the staff of International Nickel Co. research laboratory at Bayonne, N. J., as a member of the special high temperature alloys section. He was formerly chief metallurgist with Canadian Steel Improvement, Ltd., Toronto, Canada.

John R. Gorey . . . associated with Lindberg Engineering Co., Chicago, for 17 years in various capacities, has been named as administrative assistant to the general manager, Western Div., Los Angeles plant.

Gordon W. Johnson . . . has been named director of research, James B. Clow & Sons, Inc. He will be located at the research facilities in Coshocton, Ohio. Johnson was formerly assistant director, Malleable Research and Development Foundation, Granville, Ohio.

Harvey N. Barrett, Jr. . . . vice-president, Basic Inc., has been placed in charge of markets development division. He joined Basic, Inc., in 1934 and was elected a vice-president in 1953. **Warner B. Bishop** has joined the company as vice-president in charge of sales. Bishop has been a vice-president of Archer-Daniels-Midland Co. for the past five years, president of two of its subsidiaries, Federal Foundry Supply Co. and Wyodak Chemical Co. and a director of Archer-Daniels-Midland Canada, Ltd. **D. Bedell Baxter** has been appointed manager of furnace products sales, **Charles R. Heilig** and **W. B. W. Wilson** will serve under Bishop as assistant vice-presidents for general sales.

H. N. Barrett, Jr.

W. B. Bishop

Robert D. Clark . . . formerly vice-president, Northern Malleable Iron Co., St. Paul, Minn., has been advanced to executive vice-president. Other promotions are: **Donald B. Fulton,** vice-president,

Continued on page 26

let's get personal

Continued from page 24

manufacturing; **Thomas Kirby** and **John R. Entermann**, vice-president and assistant manager, sales; **Arthur W. Johnson**, general superintendent.

John E. Bevan . . . formerly with J. I. Case Co., is now chief metallurgist, Pangborn Corp., Hagerstown, Md.

E. Raymond Filosi . . . is now facilities engineer, Foundry Dept., General Electric Co., Schenectady, N. Y. He was formerly manager-manufacturing engineering for Everett-Lynn foundries.

Eugene P. Berg . . . is general manager, Link-Belt Co. Chicago operations which include the Pershing Road and Caldwell plants. Berg has been with Link-Belt since 1937 and general manager, Pershing Road plant since 1950. **T. Webster Matchett** is manager, Caldwell plant, succeeding **G. Walter Ostrand** who has retired. Matchett has been assistant manager of the Caldwell plant since Oct., 1958.

obituaries

Harold B. Gardner, 68, metallurgist for the Copper Div., Business and Defense Services Administration, Dept. of Commerce, died Aug. 7. He was formerly associated with American Steel Foundries and Bethlehem Steel Co. For the past 17 years he was employed by the U. S. Government doing research work at the National Bureau of Standards working for the Non-Ferrous Ingot Metal Institute.

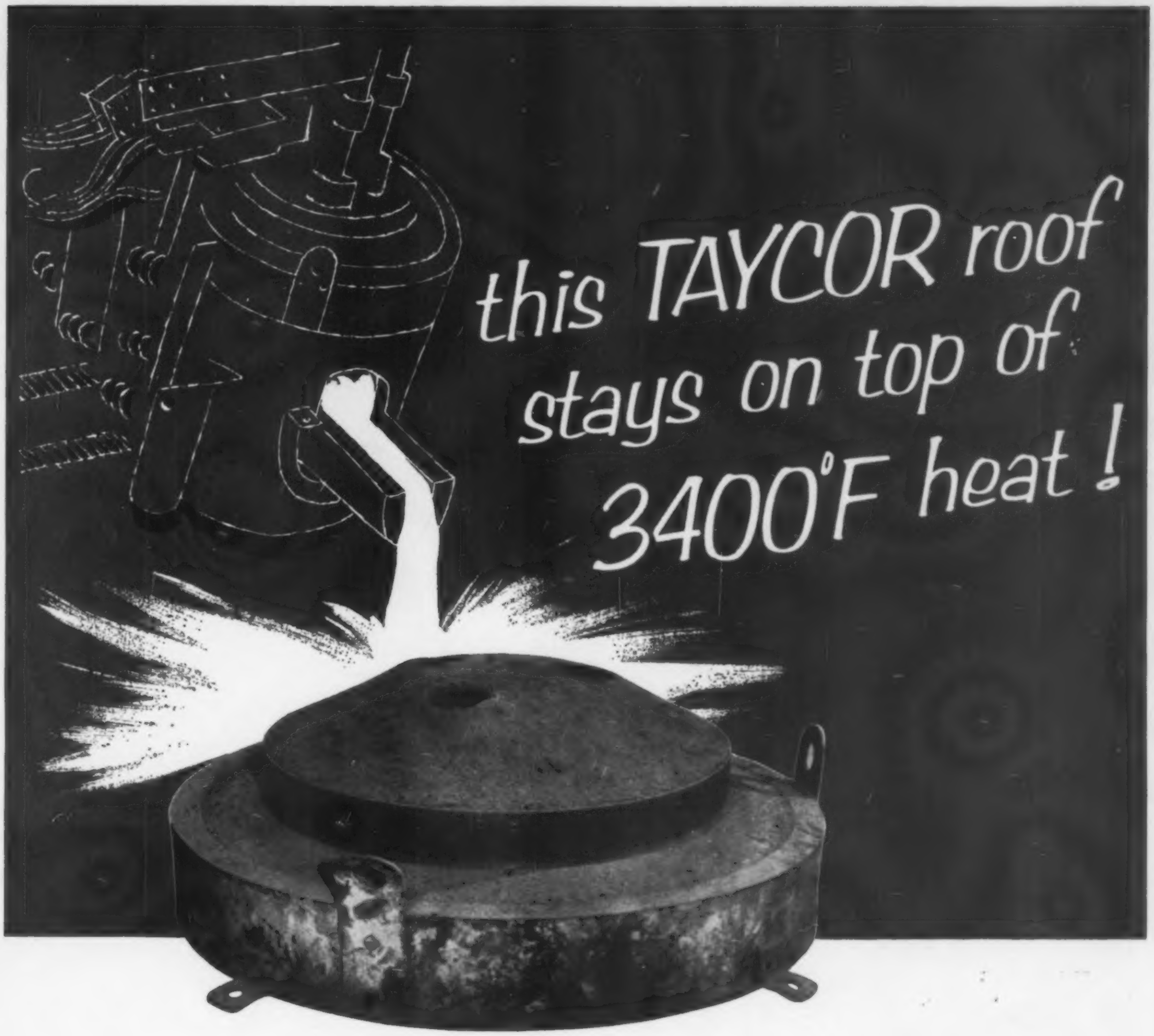
Harry L. Arnold, chairman of the board, Terre Haute Malleable & Mfg. Co., Terre Haute, Ind., died Aug. 14.

Wesley A. Miner, owner, Miner Equipment Co., Chicago, died with his wife Aug. 21 in an airplane crash. He was a member of the AFS Chicago Chapter.

Theodore E. Malpass, president, East Jordan Iron Works, Inc., East Jordan, Mich., died August 7.

William H. Gallmeyer, president and one of the founders of Gallmeyer & Livingston Co., Grand Rapids, Mich., died July 25.

Henry F. MacFarlin, 63, former chairman of the AFS Cincinnati Chapter died July 16 after a lingering illness. During his earlier years he was associated with Taylor-Wharton Iron & Steel Co., Highbridge, N. J. In 1936 he moved to Cincinnati to become superintendent of Lunkenheimer Co. gray iron and steel foundry. In 1952 he became associated with Henry M. Wood Co., Cincinnati, handling its foundry equipment.



This monolithic roof of TAYCOR Ramming Mix is for a 1000-lb. basic direct arc furnace used to melt a variety of heat-resistant alloys. Furnace operates 16 hours daily at temperatures as high as 3400° F. Extensive tests have been conducted to improve roof life for this severe application. The result of these tests proved TAYCOR Ramming Mix lasted *two to three times longer* than any other refractory. TAYCOR roof life varies from a low of 200 heats to a 900-heat record high, depending upon the alloy being melted.

TAYCOR is our trade name for Corundum-base super-refractory brick, special shapes, cements, patches and ramming mixes. The outstanding properties of TAYCOR are exceptional refractoriness, high hot load strength, superior resistance to mechanical abrasion and attack from iron oxide.

These properties make TAYCOR the ideal refractory for hearths, piers, slot bottoms, front walls, skid rails of forge, heating and heat-treating furnaces . . . for small basic direct arc furnaces operated at higher-than-normal temperatures, requiring long heats . . . for linings of indirect arc furnaces . . . for rammed crucibles of high-frequency induction furnaces. Put TAYCOR to the test in your furnaces. For further information, write direct or call in a Taylor field engineer.

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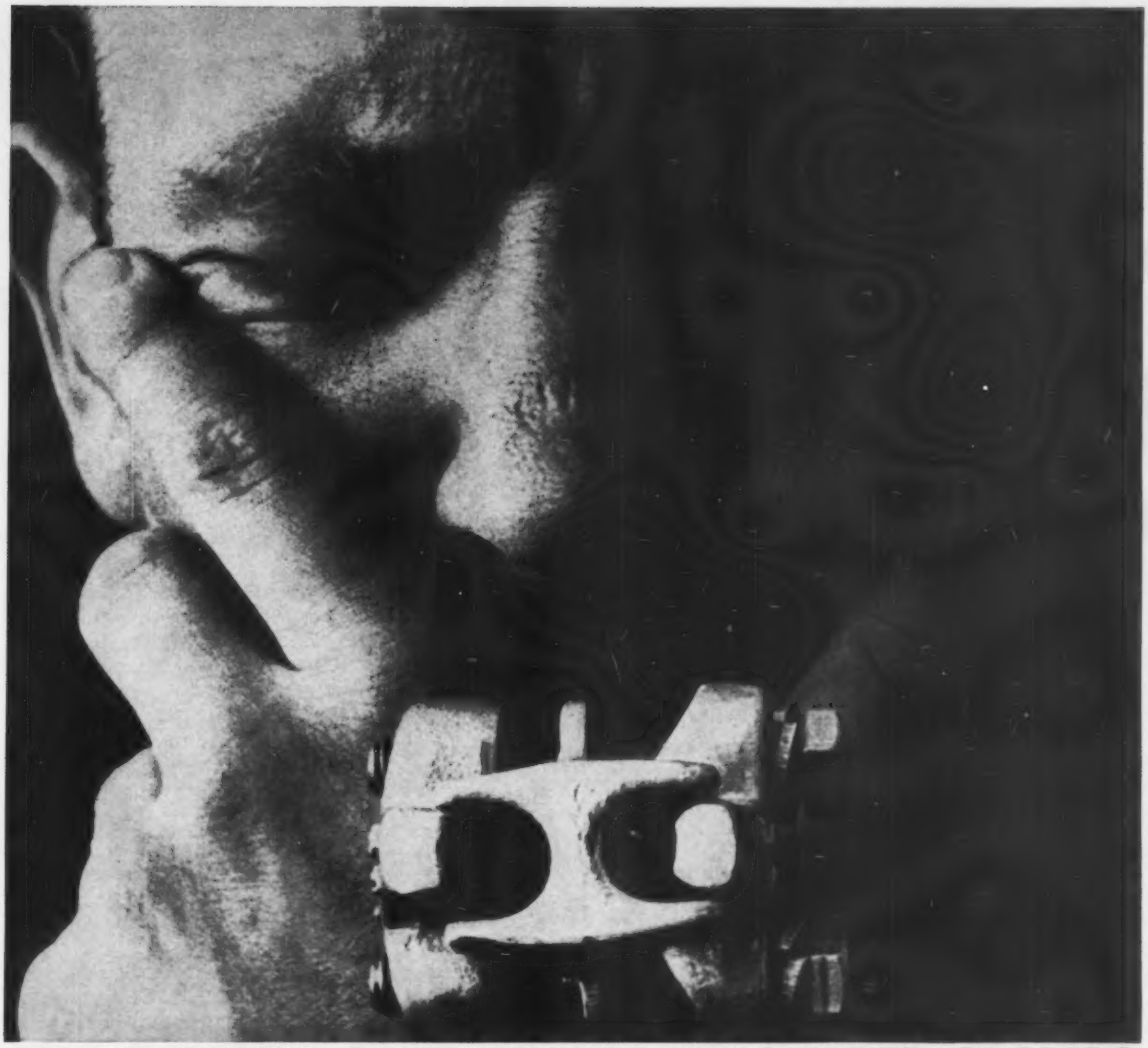

THE CURIOUS CASE OF THE FRACTURED CLAMPS

Another costly mystery solved–by the man from Kaiser Aluminum

THE PUZZLING FACTS. A customer of Kaiser Aluminum had been manufacturing an electrical connector clamp from a casting of primary standard 356 aluminum alloy. But–he often experienced difficulties due to cracking and breakage in use. What to do?

HOW THE CASE WAS SOLVED. After an on-the-scene check, the man from Kaiser Aluminum came up with the answer. His recommendation: use Kaiser Aluminum alloy A-356, a *high purity* alloy specially developed to provide greater ductility and strength in just such castings as these. Result: a superior clamp that developed a reputation of reliability for the manufacturer–and much additional business.

WE LOVE A MYSTERY. This is one of many actual cases solved by Kaiser Aluminum working with a customer. Perhaps *you* have a mystery one of our technical engineers might help solve? He's ready to give you expert advice on any casting problem–including mold and die design, alloy selection, heat treatment, finishing, fluxing, metal transfer.

FULL ALLOY AVAILABILITIES. Kaiser Aluminum can supply you *fast* with a wide selection of casting alloys to suit any engineering requirement–from general purpose, low stressed alloys to alloys having good properties at elevated temperatures.

FOR PIG AND INGOT with a free sleuthing bonus, call your nearest Kaiser Aluminum sales office now. Or write to: Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

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THE BRIGHT STAR OF METALS

See "MAVERICK" • Sunday Evenings, ABC-TV Network • Consult your local TV listing.

Circle No. 163, Page 155-156

by WALTER H. DUNN
Vice President and General Manager
Pacific Alloy Corp.
San Diego, Calif.

new look in steel castings

A quiet but important revolution is taking place in the foundry industry—particularly in the production of steel and high alloy castings. More progress has been made during the past 15 years than in any like period in history. This revolution has not only affected the production of cast products but has markedly increased the use of steel and high alloy castings in the aircraft and missile industries.

A new attitude exists toward all phases of casting production in the foundry industry. A determination to meet the new and more exacting demands are coming into use daily. Contrary to its past history, the industry is pooling its technical knowledge for the benefit of all.

The Aircraft Castings Association is an example of this movement. It is a nonprofit organization composed of a select group of foundries. Their goal is to satisfy the needs of the aircraft and missile industries and to promote the use of steel castings by these industries. Free exchange of technical information is a prerequisite of membership. The Association hopes to supply the aircraft and missile industries with needed information on the design and use of castings; also establish acceptable standard specifications for materials and inspection procedures.

New Casting Processes

Perhaps the most important phase of the foundry revolution has been the invention of new casting processes. This movement started during the second World War and is gathering emphasis as the years pass.

One of these new processes is the shell-molding process, invented in Germany just before the end of the war. Pacific Alloy Engineering produces the majority of its castings by this process. Shell molding gives unsurpassed mold collapsibility, improved finish, good tolerances and lower cost.

Fig. 1 . . . Longeron casting of type 410 steel with 1/8-in. wall.

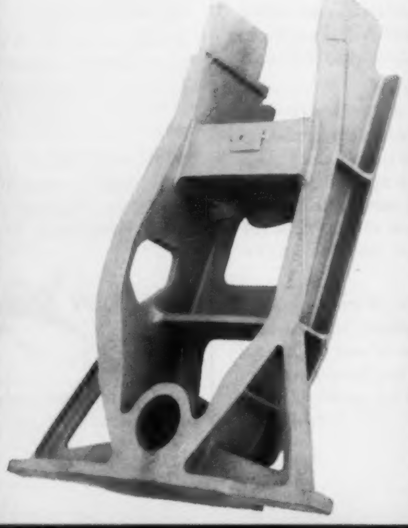


Fig. 3 . . . Cast parachute brake fitting for the Regulus missile.

Fig. 2 . . . Type 347 steel gun blast tube with 1/8-in. wall.

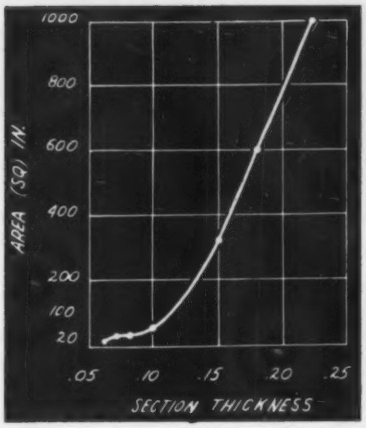


Fig. 5 . . . Minimum castable section thickness plotted as a function of area for shell molded steel castings.

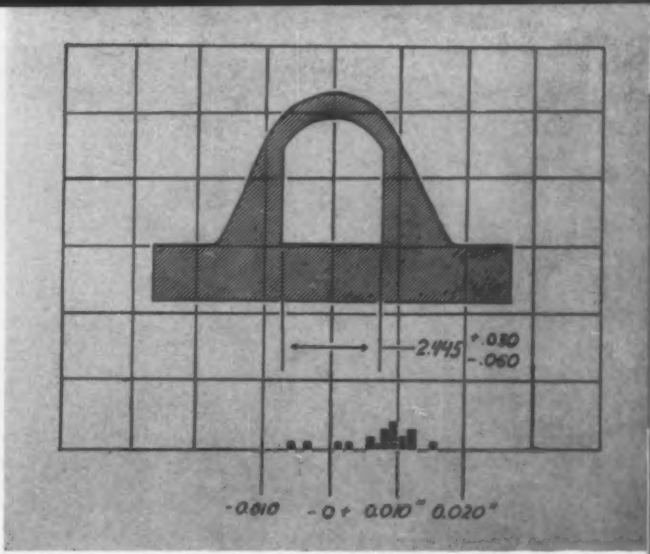


Fig. 6 . . . Dimensional spread of 20 measurements made on cored hole in 20 duplicate shell castings.

Another new process uses ceramic molds. The process is known by various proprietary names. In our case it is simply called the ceramic casting process. This process combines the materials and general technique of the lost wax investment process with the sand casting process.

Many companies are experimenting with the shell-molding process in an effort to produce shells of ceramic material having no organic bonding agents. Substantial improvements have also been made in the basic green and baked sand processes.

Better Castings

These new casting processes have contributed largely to the ability of foundries to produce parts beyond their capabilities of a few short years ago. Here are some concrete illustrations of these accomplishments. One of the big steps forward has been the increase in casting sizes while maintaining relatively thin wall sections. Pictures at top of page 30 shows an oxidizer pump for a liquid rocket engine. The upper left casting is the complete unit. The lower right casting has been cut in half to expose the cast-in blades. It is probably safe to say that none of these castings could have been produced without shell molding.

Figure 1 shows a longeron casting of 410 type steel with wall thickness varying 1/8 to 1/4 in. Figure 2 is a gun blast tube made of 347 type steel. The plate is contoured on the back and has an average wall thickness of 1/8 in.

Figure 3 is a parachute brake fitting for the Regulus missile (410 type steel, heat treated to 180,000 psi minimum ultimate tensile strength, wall thickness 1/8 to 2 in.).

As an illustration of the section thickness obtainable by this process, the chart, Fig. 5, was prepared to give some idea of castable section thickness as a function of area. This chart is only a guide since configuration has an important bearing on the section thickness which can be successfully produced.

Shell Molding

Shell molds used to produce these castings are not only quite rigid but have the advantage of good reproducibility as regards tolerances. Most of our stainless steel castings are produced in zircon shell molds. Although the cost of zircon is many times that of silica sand, the improvement in casting detail and surface finish more than justifies the additional cost. Zircon sand has the additional advantage of a more

Fig. 7 . . . Dimensional variations on parting line.

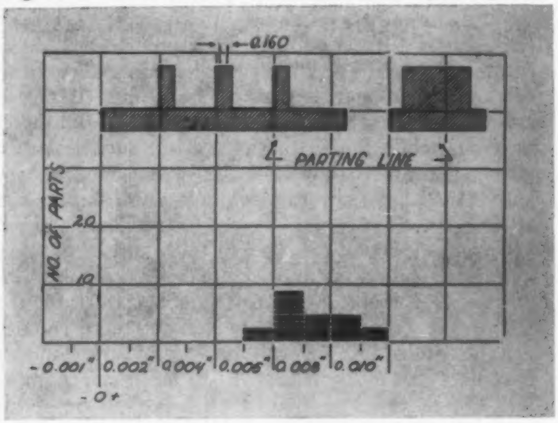
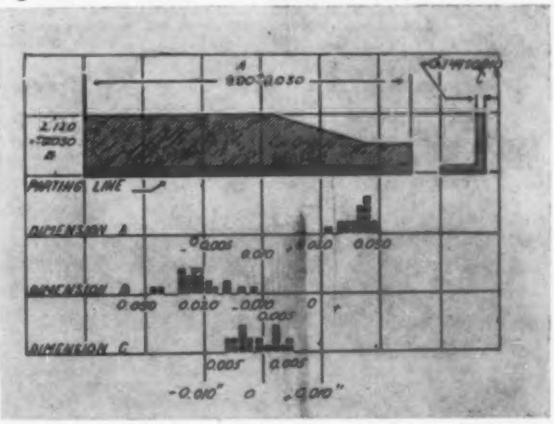


Fig. 8 . . . Effect of section size on dimensions.



Specimen No.	Reduction of Area %	Elongation %	Ultimate Stress	Yield (psi)	Hardness Rc
PA-1	47.8	18.0	222,300	187,400	44 (42-45)
-2	52.8	16.0	218,400	184,400	42 (39-45)
-3	44.5	16.3	221,000	184,500	45 (40-45)
-4	47.0	18.0	244,800	193,500	45 (39-46)
-5	44.8	16.3	200,000	166,700	43 (39-43)
-6	40.5	15.0	220,000	180,500	44 (42-45)
NPA-1			325,900		
-2			323,900		
-3			324,400		
-4			318,300		
-5			303,900		
-6			311,200		

PA-1 thru PA-6—Round, tensile specimens per BAC DWG 30-2305
NPA-1 through NPA-6—Round, notched tensile specimens per BAC DWG 30-2700

Fig. 9 . . . Tensile properties of cast AM 355.

uniform thermal expansion resulting in more dimensional stability than is obtainable with silica sand shells. The shell sand mix used at Pacific Alloy is as follows:

Zircon sand imported from Australia with a screen analysis averaging—

Screen No.	% Retained
70	0–1
100	1–8
140	40–60
200	35–55

Bond is 3.3 per cent phenolic resin. No inhibiting materials are used.

Tolerances

Variations in mold restraint and metal shrinkage caused by configuration often prevent production of the first casting within the narrow dimensional tolerance ranges requested. However, once castings are made, they can be reproduced by the shell-molding process within very close limits. If time were allowed to alter the patterns, castings could be produced within very narrow print tolerances.

In most instances the tolerances which a foundry requests in bidding a job are not a reflection of casting reproducibility. They are needed because of the difficulty in obtaining patterns which will produce a part exactly as desired.

Figures 6, 7 and 8 show some actual data obtained from shell mold castings. You will notice that in only one instance does the spread of twenty measurements fall approximately equally around the nominal dimension requested. In all other cases the actual dimensions, while closely grouped, have missed the nominal but lie somewhere within the print tolerance requested. If time had been available, this grouping of dimensions could have been moved to make it fall around the nominal print dimension. More advantage should be taken of this excellent reproducibility to eliminate machining in certain areas.

Fig. 10 . . . High temperature fatigue properties.

Spec. No.	Material	Cycle Load (lbs)	Temp. °F	Fatigue Life (cycles)	Failure
1	4340 Die Forg.	0-21,000	850	10,902	Tension across female lugs
2			850	16,668	
3			850	9002	
4			R.T.	13,105	
5	AM 350 Die Forg.	0-21,000	850	14,218	Tension across female lugs
6			850	13,821	
7			850	10,862	
8	AM 350 Casting	0-21,000	850	16,654	Tension across female lugs
9			850	17,745	
10			R.T.	12,176	Tension across rect. hole
11	17-4PH Die Forg.	0-21,000	850	4914	Tension across rect. hole
12			850	2942	Tension across female lugs
13			850	1928	
14			850	2419	
15			R.T.	10,898	

Use of Vacuum

Another phase in our research work is vacuum degassing and vacuum melting and pouring. In the vacuum degassing process, metal is air melted in an induction furnace. The entire furnace is then enclosed in a vacuum chamber and pressure reduced to approximately one millimeter for 15 minutes. The unit is removed from the furnace and castings are poured in the normal manner. In vacuum melting and pouring, the entire operation takes place inside a vacuum chamber.

Vacuum removes excessive oxygen, hydrogen and nitrogen from the molten steel. This gas removal also produces cleaner metal since the boiling action removes many impurities. Mechanical properties receive a distinctive boost from vacuum treatment.

New Alloys

Many new alloys are now or soon will be available in the cast form. The precipitation hardening class of steels, 17-4PH and AM 355, are well-known examples. These steels exhibit excellent mechanical properties. AM 355 particularly offers properties not previously obtainable in cast materials. Illustration 9 shows properties of smooth and notched tensile specimens from cast AM 355 bars.

Illustration 10 shows high temperature fatigue properties of cast AM 355 compared to various wrought metals. Both charts illustrate the results of test work performed by major aircraft companies on cast coupons supplied by Pacific Alloy Engineering.

Other alloys previously available only in the wrought form are now successfully cast. Typical of these are the five per cent chrome tool steels, such as Vascojet 1000 and Patomic M. Other steels containing large percentages of aluminum and titanium will soon be readily available. René 41 may find considerable acceptance as a cast material by both aircraft and missile manufacturers.

Paralleling these changes in processes and materials, casting dependability has shown marked improvement through closer manufacture control, the use of higher grade raw materials and tighter inspection standards. At the same time, while costs have not gone down, they have not increased at a rate comparable to the increases experienced in labor and material. So we can actually claim lower overall costs.

Castings, properly used, will fill a gap in the manufacturing processes and eliminate many costly machining operations. As more engineers are trained in the proper design of castings so that their potential can be utilized to its full limits, we are confident that steel castings will be used in increasing numbers and are destined to play an increasingly important role in the defense of our country.

do you understand workmen's compensation?

by J. A. Bloomquist
Legal Manager
Employers Mutual of Wassau
Milwaukee

WORKMAN'S COMPENSATION has not always been a part of our American industrial way of life. In fact it was only in 1911 that Wisconsin became the first state to institute a workable compensation law. Yet, for hundreds of years the wheels of justice were slowly creating an equitable relationship between employer and employee regarding degree of liability for on-the-job injuries. The history of this movement that follows will help one towards a better appreciation of the significance of our current workmen's compensation laws.

We speak of *Common Law!* What is it? *Common* means: usual; ordinary; accustomed; shared among several; owned by several jointly; also belonging or pertaining to many or to the majority. And as to *Law*, it is that which is laid down, ordained, or established. Also, it is a rule or method for actions which co-exist or follow each other; and, that which must be obeyed and followed by citizens subject to sanctions or legal consequences.

We hear of the term *Jurisprudence*. This is the philosophy of law, or the science which treats of the principles of positive law and legal relations.

The *Common Law* is the basis of the jurisprudence of the English speaking people, and it is really the creation of the Royal Courts of England. At the time of the Norman Conquest, there were Royal Courts which had authority to call up cases from the local courts. These courts, essentially courts of appeal, served to secure a national unity in legal practices and to prevent local jurisdictions from asserting a law of their own.

Common Law

Prior to the early part of the 19th century, an injured workman could bring an action against his employer at common law only. He would have to show his injury arose from the employer's *personal* negligence or because the employer knowingly employed an incompetent servant. In other words, the employer had to use reasonable care to avoid injury to others. And the employee, if injured, had to show complete freedom from any contributory negligence. The courts interpreted the rules strictly. As a result the employee rarely recovered damages for his injuries. This is because once the employee sued, the empolyer could then exercise the following defenses:

- *The fellow-servant rule.*

  If the injury were caused by a fellow-servant and if the employer had exercised reasonable care in the selection of such fellow-servant, the injured employee had no right of action against the employer and could proceed against his fellow-servant only.

- *Contributory negligence.*

  This defense was used in the majority of cases by the employer to defeat the claims of his injured employees. It meant that even if the employer failed in any or all of the duties he owed to the employee, if the employee were found to be negligent in the slightest degree, he could not recover.

- *Assumption of risk.*

  This was a practically foolproof defense for the employer if the first two defenses failed. It meant that the employee, when he accepted the job, assumed all the obvious and customary risks of the occupation. Thus, a steeplejack knew when he accepted employment there was a risk of falling.

Public Opinion

Under this concept of common law the employee had practically no chance of recovery for his injuries. As industry grew and became more complex, the number of cases entering the courts increased tremendously. The public was forced to take notice of the pain and suffering of deprived families of the injured and deceased workers. The problem was no longer one of a legal nature, but was rapidly becoming a social

one, and hence, influenced largely by public opinion. True, the injured man could still proceed against the worker himself who caused the injury. But in practice such a right had very little value.

The foregoing applied only to personal injuries. There was no remedy at common law in the case of a fatal accident, excepting under certain conditions recognized by the Fatal Accident Act of 1846 (also known as the Lord Campbell Act). This permitted an action to be brought for the benefit of the dependents, provided the deceased person had he lived, could sustain an action at common law.

The entire situation had a decided effect on the social behavior of the employee. Where he was unable to work because of injury and had to rely on a successful lawsuit, there always was the attendant delay and uncertainty. In the meantime the employee had to live. So it meant reducing his standard of living and in many instances going on public relief.

Something had to be done—that was universally agreed! The big weakness in the legislation that had been in effect up to this point involved the unsound assumption that a personal blame could always be fixed for every industrial accident. The realization that it could not be done led the way for the introduction of workmen's compensation.

Compensation Laws

Various states of our country passed compensation laws in the early part of the 20th century. The primary objective of workmen's compensation legislation is the payment of benefits to injured employees or to the dependents of employees killed in industry, regardless of who may be at fault for the accident.

The concept behind public social insurance is to confer benefits in relation to the actual needs. However, the compensation system does not follow such a principle. The amount the employee gets is really a compromise between the loss of his earning capacity and the amount needed for his support.

There are three factors which are covered in all compensation acts. These are:

1. The rate which is usually a percentage of the amount an injured workman receives under the various schedules.
2. The duration of payment.
3. The maximum amount payable.

There are also provisions for medical aid. These include operations, if needed, and hospitalization. Early legislation did limit medical aid up to a certain amount, or for a specified period of time, or both. The laws have since been liberalized in many jurisdictions. There are now 14 states providing for medical aid to be furnished without any limit as to the amount or time. In some jurisdictions, the administrative authorities may allow additional payments where there is an original limitation.

All of the workmen's compensation acts prescribe payment in case of death and also in the case of permanent total disability. These payments, however, do vary in each state. Many states provide that a specified period of time, known as a waiting period, elapse during which time compensation is not payable. This waiting period affects only the primary compensation because medical and hospital care are provided for immediately. If disability continues for a certain number of days or weeks, payment of compensation in many states is retroactive to injury date.

The American system of workmen's compensation is actually social in philosophy, but the system is private in nature—it is a matter among employers, insurance carriers, and the employees. Employers are usually free to make private arrangements for the securing of payments to their employee excepting in those states which require the carrying of insurance in a state fund. Government participation, however, is limited to administrative supervision and the disposition of disputed claims.

Most jurisdictions require the employer either to obtain insurance or to furnish proof of his financial ability to carry his own risk. There are penalties for his failure to insure or where self-insurance is not permitted. Seven states have monopolistic funds. In such jurisdictions the employers coming within the provisions of the compensation laws are required to insure in the state fund. In some instances, however, they may qualify as self-insurers.

Self-insurance only operates at its best when the employer does have a spread of risks so that he is able to enjoy the benefits of the law of large numbers. However, it then becomes necessary for the self-insurer to establish his own protective services similar to those furnished him by insurance companies. Some of these are safety engineering, nursing consultants, claim adjusting, and legal services.

Today, every state in the Union has a workmen's compensation law—the 48th becoming effective in 1949. Alaska and Hawaii had workmen's compensation laws before being admitted to the Union.

NO. 6 IN A MATERIALS HANDLING SERIES

moving foundry materials on oscillating conveyors

by George Mott/Modern Castings

Faced with the problem of reducing material handling costs and increased production on limited floor space, Wagner Castings Co., Decatur, Ill., found oscillating conveyors to be the answer to many of its needs.

Before installing the equipment, a special four-man committee made a thorough study of the in-plant situation. Committee members were William R. Messmore, plant engineer; John Wagner, Jr., product engineer; Lawrence Winnings, foundry superintendent; Gordon Snoeyenbos, director of research and development.

These men realized the versatility of oscillating conveyors which could provide a multitude of essential foundry services—conveying, screening, sorting, cooling and feeding. The compact design and low clearance requirements of such conveyors solved the space limitations and confined quarters of their installation. They are also ideally suited to handle hot sand and castings.

Pendant Line

Molds for castings weighing from ½ to 6 lb travel on four pendant-type conveyors serving 23 molders. This line produces such items as hydraulic jack bases, torsion bar anchors, clutch and brake pedals, single-throw crankshafts and washing machine parts.

After pouring molds on the pendant line they automatically drop into an under-the-floor oscillating conveyor (Fig. 1.) This conveyor is 72 ft long, 30 in. wide and 6 in. deep. Wagner has made a modification on this conveyor by inserting a dished-bottom to reduce wear occurring on the bottom of the conveyor. This conveyor, referred to as No. 7, discharges sand and castings into a bucket conveyor which raises castings to the shakeout.

In order to conserve floor space the shakeout is located 20 ft above the foundry floor. Castings empty from shakeout into oscillating conveyor No 8 which is 16 ft. long. Conveyor No. 8 discharges at right angles into No. 9 which is 53 ft long and descends from an elevation of 20 ft to 12 ft. (Fig. 3). The longest oscillating conveyor in the system is No. 10, 82 ft long and 12 ft above the floor. The overhead conveyor eliminates all interference with operations taking place on the foundry floor (Fig. 4).

At the end of conveyor No. 10, castings dump onto an apron conveyor (No. 14). Gates and risers are knocked-off on this line. Castings empty from the apron conveyor onto a series of two short oscillating conveyors, No. 16A and 16B.

A special gating system in this set of conveyors feeds the castings automatically into either one or both of two automatic continuous blast cleaning machines.

Car Line

The car line serves 14 molders and produces automobile rocker arms, lawnmower parts, small gear blanks, electrical fittings and other castings weighing 1 lb or less.

After shakeout at the floor level, the castings move

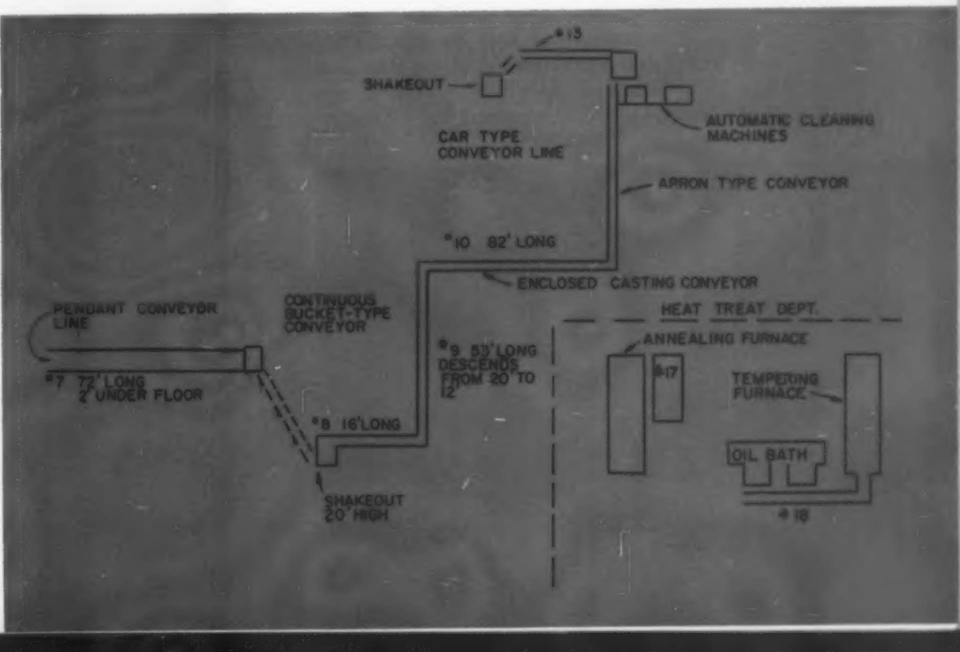
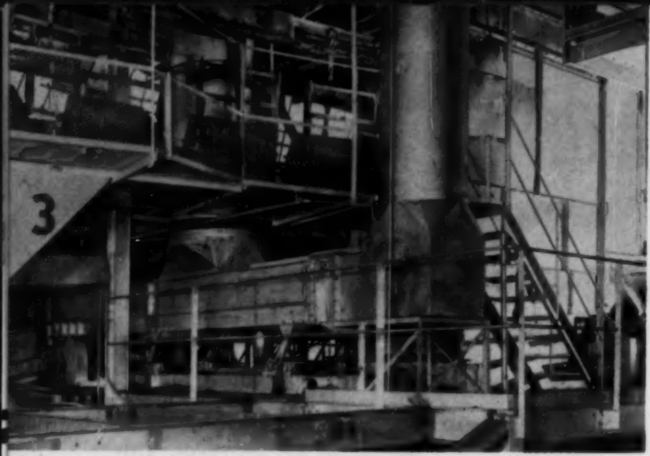


Fig. 2 . . . **In-plant study team** recommended use of oscillating conveyors now used in conjunction with two molding lines as well as in Wagner heat treat department.



by bucket conveyor to the upper level. Sand returns to storage by bucket elevators and troughed belts.

The castings then empty onto an oscillating conveyor which leads to oscillating conveyor No. 13. This spruing line conveyor is divided lengthwise to assist in separating sprue from castings. Sprue drops to ground level through a discharge door. Castings move onto a series of four oscillating conveyors, 16D, 16C, 16B, 16A leading to the continuous blast cleaning machines.

Heat Treat Room

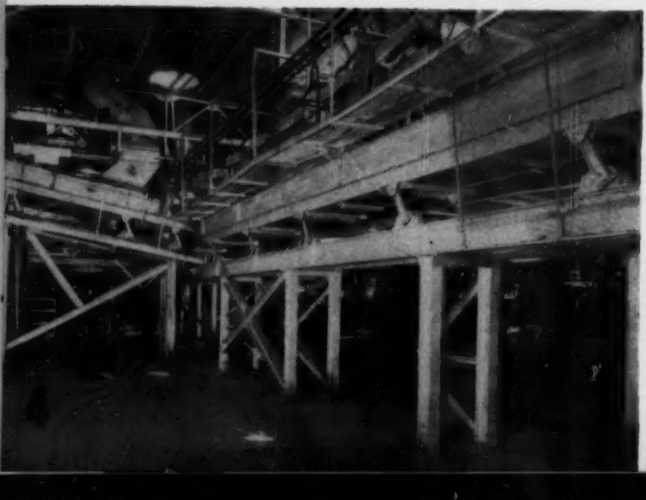
Two other oscillating conveyor installations are located in the heat treat department. One is a tandem unit for air cooling castings discharged from first-stage pearlitic malleable pusher-type furnaces.

Perforated metal beds of the conveyors are ideally suited for this operation since the beds resist both heat and abrasion. The woven-type belt conveyor formerly used was susceptible to tearing and frequently caused castings to jam.

This cooling conveyor discharges castings into metal skids for delivery to pit-type tempering furnaces or continuous hardening and tempering furnaces.

The second conveyor system moves castings from the oil quenching tanks to a continuous tempering furnace. An apron conveyor discharges castings from the quench tank onto a metal trough oscillator which solves the problem of handling oil castings.

Wagner Castings has found oscillating conveyors well suited for moving hot, rough and heavy materials in the uniform continuous flow so essential to their closely integrated operation. Add to this, low maintenance cost plus low operating cost and you have an installation ideally engineered for efficiency.



oscillating conveyors solve hot and heavy handling problems

Hot and Heavy . . . these two words describe the kind of stuff that moves along without a care in oscillating conveyors. Operational acceptance is based on the ability of these conveyors to provide a steady gentle flow of sharp, jagged, hot foundry materials and castings with practically no trough wear.

Material movement depends on a rapid upward and forward oscillating motion imparted to a metal trough. Engineered for efficiency, oscillating conveyors have a compact design with low clearance requirements which permit installation in confined quarters. Design is further enhanced by the ability to enclose the metal troughs with dust tight covers. These conveyors are particularly suited to moving red-hot castings and sand from the shakeout area to the sorting, cooling and cleaning areas.

Steel troughs are ruggedly mounted to withstand the high surge loads created by dumping heavy molds and castings onto the conveyor. Grizzly sections permit separation of sand from castings. Perforated troughs allow air to be blown up through the castings for cooling purposes. Hoods are easily provided for removal of dust and heat. Air quenching following heat treatment is facilitated by oscillating castings on a grizzly or perforated trough. Castings may be moved to and from cleaning as well as past sorting and inspection via oscillation.

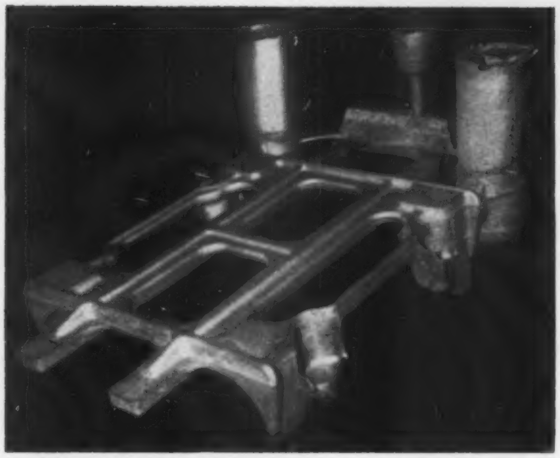
The montage of pictures surrounding this story visually demonstrates the variety of services that oscillating conveyors can perform for your foundry. A wealth of information is available to you from all the manufacturers of oscillating conveyors . . . just circle No. 240 on the Reader Service Card, last page of this issue, and you will soon have a complete portfolio of technology to solve your hot and heavy materials handling problems.

"... the principles of good design for quality castings apply to ductile iron as well as to other metals... but deviation from these principles is more likely to cause trouble in ductile iron than in gray iron ... Buyer, patternmaker and foundryman should cooperate closely while the casting is still in the design stage ... Deuscher Foundry uses quality control methods that ensure ductile iron castings of consistent physical properties true to shape and good appearance ..."

by S. F. Levy/*Metallurgist*
The H. P. Deuscher Co., Hamilton, Ohio

Light section castings that are carbidic as-cast will grow on annealing. So use a common rule instead of a shrink rule when making patterns for such castings in order to have the correct dimensions in the finished castings. On complicated shapes where there may be some restraint to shrinkage, trial and error is sometimes the only way to arrive at correct pattern dimensions.

Before a pattern is put into production, study it carefully for location of gates and risers. Well designed gating systems eliminate turbulence in metal flow and prevent dross from entering the mold cavity. Riser diameters should equal section size (being fed) plus 2 in. The riser neck should be slightly less than section size and as short as possible—not over one-third the riser diameter. Gating through a riser has proven the most effective way of feeding ductile iron castings. Top risers are avoided as much as possible. Feeding is often aided by use of an exothermic material for covering risers.



Gating through risers has proven to be the most effective way of feeding ductile iron castings.

Quick check on each ladle can be made with test bar poured after silicon inoculations. Ductile iron fracture will have steel gray appearance.

Raw Materials

Carefully select and control your raw materials for ductile iron production. If operating an acid cupola, keep sulphur in the raw materials as low as possible. Low sulphur content is a must for the base iron. Select pig iron on the basis of the proper silicon content, with sulphur, phosphorus and manganese as low as possible. This means phosphorus of 0.03-0.04 per cent, manganese 0.25-0.30 per cent and sulphur around 0.02 per cent.

Structural steel scrap and rail scrap are generally used. Any steel suspected of containing alloys is not used. All ductile iron returns are segregated and used as melting stock for ductile iron. Our metallic charge contains 30 per cent pig iron, 30 per cent steel and 40 per cent returns.

The coke used is 92.0-92.5 per cent fixed carbon and approximately 7 per cent ash, with sulphur about 0.55 per cent. Limestone is the only flux used.

Melting and Metal Treatment

Daily ductile iron production in the Deuscher foundry is 1-3 tons out of a total daily production of around 20 tons. Iron is melted in a 48 in. (inside) diameter cupola, using a 48 in. coke bed and an air volume of 4300 cu ft per min, controlled by an air-weight controller. Metal charges are 1000 lb, with 100 lb of coke between charges. Two gray iron charges are placed in the cupola first, then a double coke charge is put in before the first ductile iron charge. An amount of limestone equal to 2 per cent of the coke charge is also added.

Pouring two gray iron charges ahead of the ductile iron serves to heat the ladles. The double coke charge before the ductile iron not only acts as a separator but also furnishes additional carbon for the ductile iron.

Iron is tapped from the cupola in the range of 2800-2850 F. This higher temperature is needed because of the amount of handling necessary to make ductile iron. Unfortunately, magnesium recovery decreases as the temperature of metal treated increases. Iron is tapped from the cupola, weighed and then reladled onto the weighed magnesium alloy in another ladle. When the reaction subsides, the ladle is carefully skimmed. The iron is again reladled with ferrosilicon added to the metal stream.

All additional materials are carefully weighed. Alloy additions, based on weight of metal to be treated, consist of 0.5 per cent nickel-magnesium alloy, 1.5 per cent nickel-silicon-magnesium alloy and 1.0 per cent ferro-75 silicon. The amount of metal treated at one time varies from 1200 lb-1800 lb. The magnesium alloys are 3/4-in. x 8 mesh in size, and the ferrosilicon is 3/8-in. x 12 mesh.

Metal Composition

Base iron (as tapped) has the following analysis:

Silicon	1.00 to 1.25 per cent
Sulphur	0.10 to 0.11 per cent
Manganese	0.25 to 0.35 per cent
Phosphorus	0.02 to 0.04 per cent
Total Carbon	3.50 to 3.60 per cent

Chemical analysis of the treated iron is:

Nickel	approximately 1.5 per cent
Silicon	2.25 to 2.50 per cent
Manganese	under 0.35 per cent
Phosphorus	under 0.08 per cent
Total Carbon	3.50 per cent or higher
Magnesium	approximately 0.06 per cent

Total carbon is determined on 1/8-in. pencils poured in an iron mold so that all carbon is in the combined state. Drillings will always give low results because of graphite loss when drilling the sample.

Gates and risers are easily removed at Deuscher Foundry through use of high-speed cut-off saw shown here in action.

Microscopic examination is made for graphite shape, pearlite, ferrite, and inclusions.

Chemical analyses of test bars from treated iron are made along with physical tests and microscopic examinations. Thus all are considered together to aid in control. The elements most closely watched are silicon, phosphorus and magnesium. Nickel and manganese are determined less frequently.

Tests for Quality of Treated Metal

As a quick check on each ladle of iron a small test bar is poured after the silicon inoculation. This test bar is the same 1/4-in. x 1-1/2 in. x 4-1/2 in. chill test bar that is used for gray iron, except the core mold is set on dry sand instead of pouring against a chill block. This test bar can be quickly cooled and broken. If ductile iron has been obtained, the fracture will be steely gray and quite distinguishable from gray iron.

Keel blocks are poured from every heat. Legs cut from them are used to determine physical properties. Usually one leg is cut off the block in the as-cast condition. Then the block with the other leg attached is annealed with the castings. Specimens from the keel blocks are checked for microstructure, Brinell hardness, tensile strength, yield point and elongation.

Microscopic examination is made for graphite shape, amounts of pearlite and ferrite present and excessive amounts of inclusions. Slag or dross inclusions cause irregularly shaped graphite particles that are neither distinctly flake nor nodular. Unless present in large amounts, these inclusions do not seem to seriously impair the physical properties.

If castings are to be annealed, the proper cycle must be chosen. Castings containing carbides must be held at 1600-1650 F long enough to break down the carbides—usually 1 hr per in. of section. Furnace temperature is then reduced to 1275-1300 F to break down the pearlite. Castings that do not have primary carbides in the structure may be annealed at the latter temperature. In the Deuscher foundry, annealing is done outside the plant. Each batch of castings sent to the annealer contains pieces that range in size from light to medium or heavy sections. So a standard cycle has been chosen that will insure complete annealing of all the castings.

Heat Treatments

This cycle is:

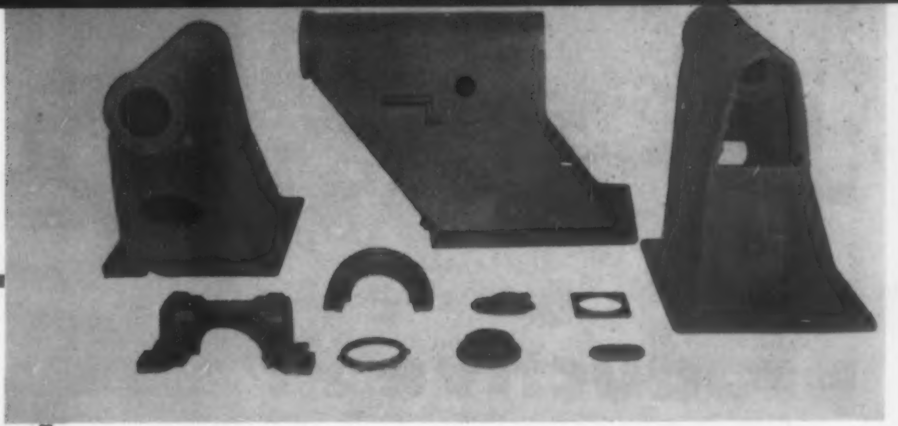
1) Heat to 1650 F and hold 4 hr.
2) Drop to 1275-1300 F and hold 6 hr.
3) Furnace cool.

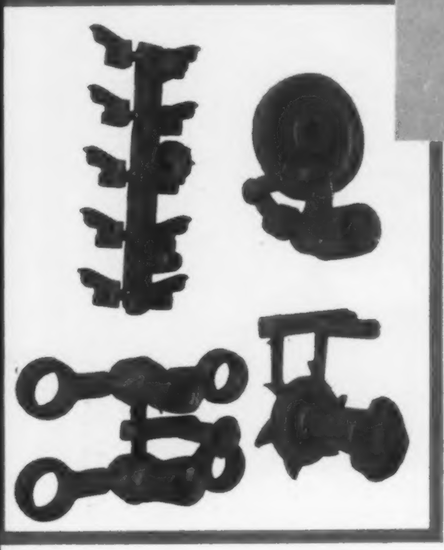
Keel blocks, annealed with the castings and sections from questionable castings are checked after annealing by microscopic examination and Brinell hardness tests.

Long, thin castings and castings of intricate shape must be adequately supported during annealing to prevent distortion. Small castings are often packed in dry sand to avoid distortion caused by having other castings placed on top of them. Castings of complicated shapes that do not require annealing are stress-relieved at 1100-1200 F.

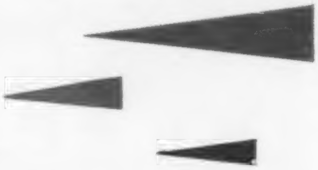
A good furnace with a good control system is necessary for consistent heat treating results. If annealing is done outside the plant, choose a plant with good equipment.

Table shows typical ranges of physical properties for as-cast and annealed specimens taken from keel blocks.





Quality control not only improves customer relations but also allows pinpointing of trouble so that corrective steps may be initiated.



Gating systems that are properly designed perform the dual function of eliminating turbulence in metal flow and keeping dross from the mold.

Table 1 — PHYSICAL PROPERTIES RANGE

Property	As-Cast	Annealed
Tensile	90,000-100,000 psi	65,000-75,000 psi
Yield	65,000-75,000 psi	42,000-55,000 psi
Elongation	3-8 per cent	15-20 per cent
Brinell	245-265	160-180

Hardness Tests

Brinell hardness readings are taken regularly on legs cut from the keel blocks both in the as-cast and annealed condition. A shop should determine the hardness range for its ductile iron, as-cast and annealed. Then this test serves as a rapid nondestructive test to help keep the process under control.

Any variations from the usual hardness range in the as-cast state, if lower than normal, may indicate the presence of flake graphite and if higher than normal, may indicate more pearlite or carbides than usual or an increase in silicon or nickel. Brinell hardness of annealed test bars and castings will indicate whether or not annealing is complete. Checks of the microstructure and chemical analysis should show the reason for hardness variations outside the normal range.

The same sand control methods are used for ductile iron as for gray iron. By way of emphasis, however, remember to maintain low moisture content and sufficient carbonaceous material to minimize the occurrence of pinhole defects in light ductile iron castings.

Inspection and Records

Inspection of ductile iron castings begins on the cleaning floor prior to the first cleaning operation and continues after each operation, including shipping. Considerable savings can be effected by eliminating defective castings before they are annealed and recleaned. So inspection prior to annealing is rigorous. Cleaning department employees watch for defects as the castings go through their department. The shipping clerk also inspects the castings before sending to the annealer or to the customer.

The supervisory and metallurgical staffs also keep a close watch on castings in the cleaning room—especially on new jobs and those that have caused trouble in the past.

Records are kept of each ductile iron heat, in addition to the regular daily cupola record. The ductile iron heat record includes makeup of the charge, amount of additives used, physical and chemical tests and castings poured. Records are also kept of all defective castings broken down by causes. A similar record is kept of all castings rejected by customers. This recording of significant information, and the use of it in tracing and correcting casting troubles, is a useful tool for quality control.

Conclusion

The scope of quality control varies from one foundry to another, depending on the requirements of customers and the time, equipment and personnel available. The Deuscher foundry has a laboratory with sand-testing equipment, a Brinell machine and a microscope with essential polishing equipment. A commercial laboratory is used for chemical analyses and physical tests. Quality control methods have been chosen that will ensure ductile iron castings of consistent physical properties, true to shape and good appearance.

The writer wishes to acknowledge the cooperation of H. O. Ehresman, Jr., assistant metallurgist, in preparation of this article.

productive maintenance ...1960

You might wonder at the significance of the title "Productive Maintenance–1960." Maintenance as commonly practiced in past years is very definitely on its way out and has no place in 1960 and the years to come. The tempo of American industry has been cranked up another notch higher by the jet age in commercial transportation, the dawn of the space era, ICBM missiles, moon rockets, man-made satellites, etc. These factors are pushing toward an entirely new concept of maintenance.

During the next ten years it has been estimated that this country's gross national product will increase by perhaps 40 per cent. However, during this same time the available direct labor force is expected to increase only 12 per cent or less. This means that American industry will have to find ways and means to increase the output of its production workers. As the requirements build up for greater production, we will see more industries, including your own foundries, boost the output per worker by the installation

A complete record of what you have and where you have it is necessary if your productive maintenance record system is to control maintenance costs.

Maintenance Questions — 1960

Foundries today are spending millions of dollars for new equipment designed to perform operations faster, better and more efficiently. However, all of this beautiful and expensive machinery is worthless and becomes an expensive drag on profits unless it can be kept in production on a planned schedule. Such equipment must be maintained in a manner entirely different from that which has been prevalent in industry for many years.

of new and improved electrically operated machinery and equipments. As a foundry begins to mechanize, maintenance of machinery and equipment becomes more and more critical. As industry goes forward toward true automation, the investment in machinery per unit output rises at a rapid rate. And the shareholder sees no return on his investment unless the equipment is producing as planned. Under such conditions, unplanned outages or shutdowns can prove disastrous.

by C. E. Sutton, Jr.
*General Electric Co.
Schenectady, N. Y.*

Dust and sand and carbon particles which are present in all foundries are not conducive to long life of motors, generators and other electrical and mechanical equipment.

Take for example a 9000 KW electric furnace which represents a total investment of close to $500,000. It is interesting to note that this furnace is supplied from its own bank of power transformers; is controlled and operated by 7 or 8 motors in sizes 100 HP and below; is complete with amplidyne control for the electrodes; contains a special stirring system operated by inductive currents supplied from a special motor generator set and controls. All told, this furnace is a key item in a large foundry.

We might ask ourselves: what happens if one of the main motors were to fail? How quickly can it be replaced or repaired? Are the motors, generators, transformers and control inspected on a regular planned basis? Is the equipment overhauled at frequent intervals? How much does unplanned down-time cost per hour? If this were your furnace, could you answer these questions—and would the plant manager be happy with the answers?

Many large and modern foundries are equipped with a sand slinger which can throw one ton of sand per minute and can ram molds better and faster than fifteen men. Such a machine might use 4 to 6 main motors and represents an installed investment of $40,000 to $60,000. The failure of any one motor completely shuts down this machine and that part of the foundry is idle until it runs again.

Failure of the impeller motor might possibly shut the machine down for as long as *one week* while the machine was dismantled to get to the disabled motor, make necessary repairs and reassemble the machine. However, this 7 day down-time could be reduced to 2 days if a complete spare ram head (including motor and shaft) could be carried in stock. But this spare part costs $4000. Is this a wise decision? Could you justify this expenditure in your plant?

A shell molding installation employing 2 mold making machines, one mixer and two shell closers represents an investment of about $250,000. All of the equipment is motor operated. How often are these crucial motors inspected? What records are kept on the replacement parts required? What replacement parts or complete replacing motors are in stock? How long does it take to pull off a disabled motor?

In most large foundries today the sand system is motorized and carries sand around the plant on a conveyor system. This equipment could represent an investment of $100,000 or more; and usually the entire output of a foundry hangs on its performance. What provisions have you made to keep unplanned down-time to a minimum if unexpected repairs have to be made to the electrical or mechanical portion of your sand system?

At this point we might stop and ask ourselves the overall general question—have our maintenance methods progressed as fast as the mechanization or automation in our foundries?

How Much for Maintenance?

For many years maintenance has been looked upon as an expense which had to be faced and endured when money was available. When business slowed down it was one of the first items to be cut to the bone. Modern thinking now looks on proper mainte-

Report analysis can schedule routine work such as motor lubrication.

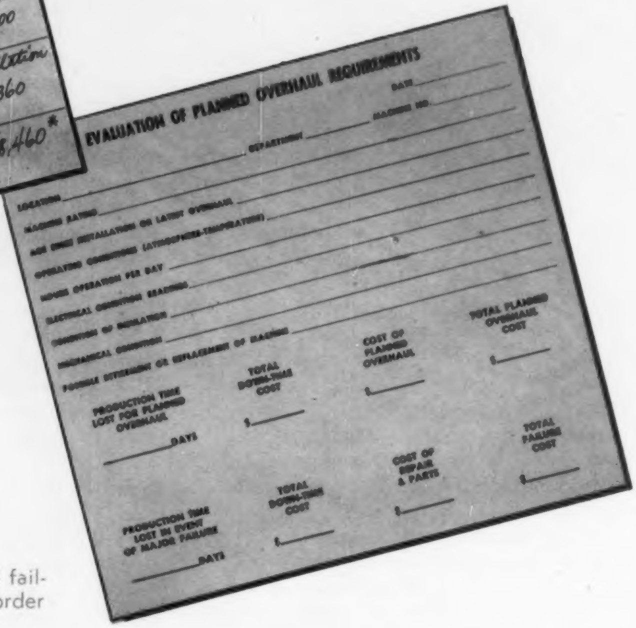
Optimum turnover rates will be achieved through use of an up-to-date inventory record system.

EVALUATION OF CRITICAL PARTS PROTECTION REQUIREMENTS

(The Evaluation is based on the failure of a part which requires the longest repair time such as armature coils)

	NO MAJOR PARTS STOCKED	ARMATURE COILS STOCKED	COMPLETE ARMATURE STOCKED	COMPLETE MACHINE STOCKED
REPAIR TIME	10 days to make coils x	6 days to rewind armature x	7 hours to install new armature	8 hours to replace motor
TOTAL DOWNTIME COST	$168,000	$100,800	$4,900	$2,100
COST OF PARTS PROTECTION	0	Coils: $4,664	Armature $25,600	Motor $46,000
COST OF REPAIR	$12,730	$5,900	Installation $850	Installation $360
TOTAL FAILURE COST	$180,730	$111,364	$31,350*	$48,460*

Critical parts whose failure may result in many hours down time should be evaluated to determine what parts to stock.



EVALUATION OF PLANNED OVERHAUL REQUIREMENTS

DATE ________ DEPARTMENT ________ MACHINE NO. ________

LOCATION ________

MACHINE RATING ________

AGE SINCE INSTALLATION OR LATEST OVERHAUL ________

OPERATING CONDITIONS (ATMOSPHERE-TEMPERATURE) ________

HOURS OPERATION PER DAY ________

ELECTRICAL CONDITION READINGS ________

CONDITION OF INSULATION ________

MECHANICAL CONDITION ________

POSSIBLE RETIREMENT OR REPLACEMENT OF MACHINE ________

PRODUCTION TIME LOST FOR PLANNED OVERHAUL ________ DAYS

TOTAL DOWN-TIME COST $________

COST OF PLANNED OVERHAUL $________

TOTAL PLANNED OVERHAUL COST $________

PRODUCTION TIME LOST IN EVENT OF MAJOR FAILURE ________ DAYS

TOTAL DOWN-TIME COST $________

COST OF REPAIR & PARTS $________

TOTAL FAILURE COST $________

Total overhaul costs can be compared to total failure costs with this chart. List equipment in order of critical importance.

nance as an element of cost and an item which should be pro-rated over the number of units or output produced from a factory. A maintenance system properly operated should result in the minimum maintenance cost per unit. The system employed should be capable of producing unit cost figures which may be used in determining whether too much or too little money is being spent for maintenance. Additional money certainly should be spent if increased expenditures for maintenance will reduce down-time so that annual plant output can be increased to a point where the unit cost of maintenance decreases.

A good maintenance system should increase production, reduce unplanned down-time and serve as an item of cost reduction rather than one of necessary expense.

Many industrial plants today are critically reviewing the comparative cost of maintaining captive repair facilities within the plant versus sending the electrical and mechanical repair work outside to a professional repair or service organization. The captive operation is usually justified on the basis of lower cost as compared to sending the work outside. However, you might be amazed at the actual cost of parts and repairs made in a captive shop if the costs includes all elements such as overhead, proportionate share of rent, heat etc., cost of carrying inventory, investment in tools and equipment, cost of pension plans, fringe benefits for employees, etc.

Admittedly, it takes up-stream thinking for a plant manager to discontinue an operation which might have been in existence for a long time in his plant. But today more and more industries are finding that they cannot afford the luxury of a captive repair shop when their basic business may be that of running a foundry, making steel, running a railroad, etc. Remember that a commercial shop must do the job quickly, correctly and at a reasonable price or lose the work to a more competent competitor. A captive shop also has a captive customer and lacks both the profit motive and competitive angle so necessary to keep a business on its toes.

When to Maintain

The boom or bust philosophy on maintenance is gradually going out of the window in today's highly competitive operations. Industry is beginning to realize that periods of recession, or slow business, are the ideal times to go in and inspect, modernize and overhaul necessary equipments. When business calls for normal operations, then the plant can roll with up-to-date, modern equipment without the fear of unexpected and costly shut-downs for equipment repairs.

In general, repairs and overhaul work can be performed at minimum cost when business is slow. The equipment can be made available on a planned basis without the necessity for round-the-clock, expensive overtime premiums normally associated with

rush repair and overhaul work performed when production is urgently needed. In periods of slack business, the equipment can be inspected, the job planned and improvements incorporated which might not be possible when the equipment is being worked on under an emergency basis.

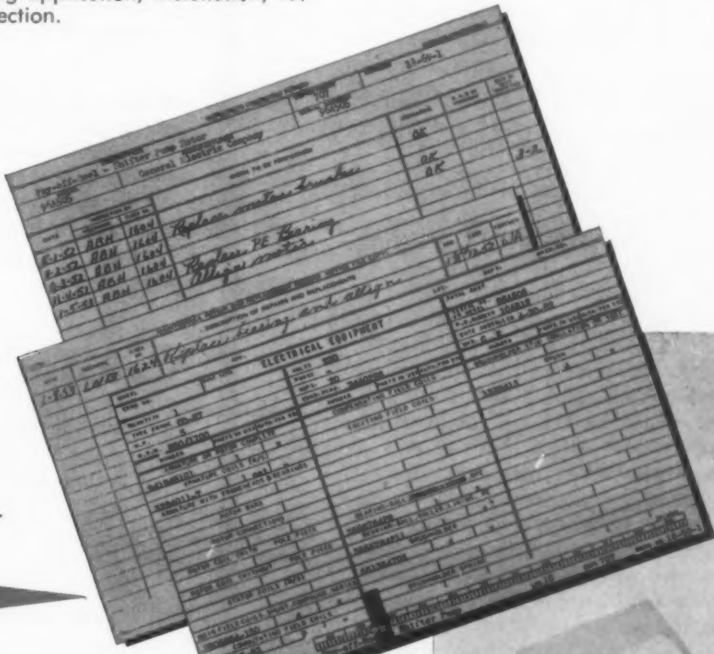
Protective Maintenance

If at this point we are in agreement that many factors today make maintenance an increasingly important item in a foundry, then what is the best, single system to put into effect? There may not be any one best system. But much has been written and many plants today are using the well known Productive Maintenance system or a modification thereof. This system is designed around the concept of maintaining equipment so that down-time is minimized. The five basic steps in a Productive Maintenance program are:

- **Step 1 Gather complete equipment data.** No maintenance system can be effective unless the location of equipment, its nameplate rating, characteristics, age etc. are known and recorded.
- **Step 2 Determine the extent of routine maintenance.** This again is elementary. The beginning of any good system is the establishment of a routine program for regular inspection, lubrication and minor parts replacement on the equipment which has been previously listed and cataloged under Step 1.
- **Step 3 Establish a routine operating control system.** An effective system requires that records be kept to insure the orderly and efficient purchasing and stocking of minor parts, maintenance cost control and manpower planning.
- **Step 4 Evaluate for critical maintenance.** At this point Productive Maintenance pulls away from usual maintenance systems and lends itself to being tailored for the industry and plant in question. Also at this point top engineering judgment is required to insure the maximum effectiveness of a Productive Maintenance Program. In this step a list is made of each piece of equipment in the order of its importance to production. The costs of break-downs and the effects of down-time for each piece of critical equipment must be balanced against the cost of stocking standby parts, or, perhaps complete machine replacements. This information is essential in order to determine the best protection for the productive system at the least cost.

Unfortunately, foundries have the least information in this area. In discussing this point with a multi-million dollar manufacturing plant, plant management admitted that no effort had been made to evaluate the cost of down-time for certain

Your equipment record system should include information regarding application, installation, rating, parts and inspection.



Inventory control system for each part can tell you when to re-order and also provides control against costly duplication.

critical machines in their plant. Hence no real engineered plans had been made to keep this down-time to a minimum.

- **Step 5 Establish a critical maintenance program.** Here the decisions arrived at in Step 4 are put into effect. Definite budget plans can be made to establish a plant-overhaul program of critical equipment which might be projected over a 5 to 10 year period to permit the systematic upgrading and modernizing of producing equipment. This step eliminates the danger of some day finding an entire line or process that requires immediate overhauling to reduce the danger of a complete shut-down.

Conclusion

Obviously the proof of the effectiveness of any proposed system is in the actual operating results. Fortunately, Productive Maintenance as proposed, lends itself to many modifications and is flexible enough so that it can be adapted to almost any type of industrial operation. For example, a recent report was prepared by the Atomic Products Operation at Richland, Washington entitled "Productive Maintenance as Applied to Reactor Area Facilities". This program has been in operation approximately two years with highly satisfactory results.

In discussing maintenance at a highly automated foundry the engineer pointed out that a Productive Maintenance program has been in use for several years and is enthusiastically backed by the production foreman inasmuch as it has resulted in a considerable increase in production. In their particular system IBM records are kept on each machine. So those machines requiring excessive maintenance can be spotted and necessary steps taken to investigate and correct the trouble.

One of the real secrets in the successful operation of a Productive Maintenance system is the selection of the proper level of responsibility in the organization for the Maintenance Program. The man in charge of this operation must be on a par with engineering, purchasing, sales, accounting etc. He must be in a position where he can properly evaluate the effect of unplanned down-time on production, sales, inventory, incoming raw materials and competitive position. He should be in a position to evaluate the comparative costs of repairing existing equipment versus purchasing new equipment while factoring-in depreciation and tax considerations.

The cost of down-time versus carrying renewal parts or complete replacing equipment must be analyzed and the best answer selected. The proper man in charge of such a program doesn't necessarily have to be the executive vice president but such matters certainly cannot be decided by the man on the shop floor with the oil can and grease rag.

The economists tell us that 1960 will see industry shake off the last traces of the recent recession and again resume its steady rate of expansion. With increasing demand for products, increasing competition, increasing squeeze on profits, and increased use of mechanization and automation, PRODUCTIVE MAINTENANCE–1960 gives promise to holding the key to profitable operation.

1959 CASTINGS CONGRESS PAPERS

■ The technical articles appearing in this preview section of Modern Castings are the official 1959 AFS Castings Congress papers–the most authoritative technical information available to the metalcasting industry.

Nearly 100 technical papers presented at the 63d Castings Congress of the American Foundrymen's Society will be printed here prior to publication of the complete 1959 AFS Transactions.

■ Written discussion of these papers is welcomed and will be included in the 1959 Transactions if submitted by September 1. Discussions should be addressed to the Technical Department, American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill.

■ The complete case-bound volume of 1959 AFS Transactions, including all papers and all discussion, will be published in January, 1960. Orders for this volume should be addressed to the Technical Department.

APPLICATION OF PRESS FORGED CASTINGS

By P. Gouwens, T. Watmough and J. Berry

ABSTRACT

Recent developments have proven the feasibility of a duplex process for creating high strength metal shapes. This process is a combination of casting and press forging at selected temperatures to obtain a final part which has unique properties and advantages. The first part of the process consists of making a casting by conventional quality foundry practice. This casting will be so dimensioned that the deformation imparted to it by subsequent forging will result in a correctly shaped and sized final part.

Therefore, the casting would correspond in forging parlance to the last-stage forging blank. Proper heat treatment would then be employed to put the metal in a solution-treated or austenitized condition prior to press forging. Forging is done isothermally at temperatures below that which would result in recrystallization but which would influence other metallurgical reactions.

It is noteworthy that the forging stage of this process differs from conventional hot forging. The usual hot forging work is done at temperatures high enough to impart almost unlimited ductility to the metal and a low flow stress. This makes for ease of forming and freedom from metal rupture during forming. In addition, the metallurgically active condition of the metal results in rapid recrystallization and its accompanying relief of strain-induced hardening, so that this strengthening mechanism is largely absent in a normally finished forging.

INTRODUCTION

Technically speaking the forging work discussed in this duplex process, since no recrystallization occurs, is properly termed cold-working, even though temperatures up to 800 F are employed. These higher temperatures impart easier deformation characteristics to the part than with cold-working, but also result in a degree of relief from the strain-hardening effect. However, these factors are not the reasons for selection of specific temperatures for the press-forging operation.

Instead, the temperatures selected are based on potential metallurgical structure changes with time. The work can affect the orientation, size and distribution of hardening nuclei and, in addition, can shift the time and temperature at which structural changes occur. Strength benefits are likely to accrue as a result of these changes.

The objectives of this process are to modify the mechanical properties of castings without unduly reducing their economic advantages. Specific advantages possible are as follows:

1) Higher ultimate tensile strengths, even up to ultrahigh strength levels when compared to heat treated castings of the same composition.
2) Corresponding increases in yield and proof strength without the same degree of ductility decrease usually associated with strengthening by heat treatment only.
3) Relative freedom from the marked directional properties encountered in most forgings.
4) Better resistance to impact and fatigue loads at normal temperatures.
5) Reduced lead time and costs when compared to forgings for short run or prototype parts.

LITERATURE BACKGROUND

The technical literature contains information pertinent to the press forging of castings. Sims[1] made a comparison between the mechanical properties of SAE 4100 steel castings and forgings, one aspect of which included the use of cast forging blanks. Where unsound castings were used, worth-while improvements in mechanical properties resulted; but sound castings gave only a minor improvement after forging. Conventional hot forging techniques were used. He further reported that this practice of casting forging blanks was prevalent in captured World War II German material, both in ordnance and in aircraft. An economic appraisal of the combination process was favorable to it.

The effect of strain on the rate and temperature of metallurgical reactions in certain metallurgical structures has long been known qualitatively, but quantitative investigations of the influence of such strain-induced structures on the mechanical properties are of recent vintage. Thus the warm working of an age-hardenable austenitic steel by Harris and Bailey[2] in the precipitation temperature range of 1292 to 1472 F increased the proof stress from 31,400 psi to 72,800 psi. The maximum aged strength without the forging work was only 44,800 psi.

Lips and Van Zuilen[3] using a 4.5 per cent Ni, 1.5 per cent Cr, 0.35 per cent C steel obtained tensile strengths in excess of 400,000 psi with 42 per cent reduction in area. This compared with heat treated properties of 295,000 psi and 5 per cent reduction in area. This tremendous improvement was obtained

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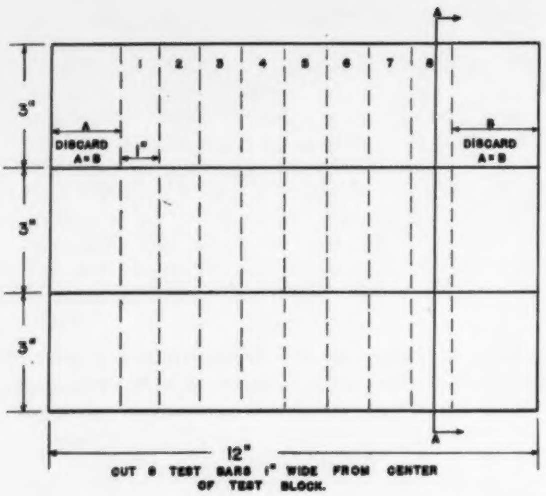

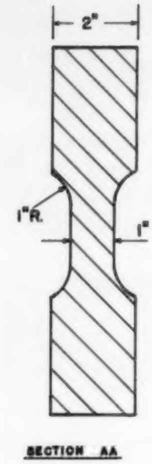

Fig. 1 — Test block casting.

by forging metastable austenite below the recrystallization temperature.

Schmatz and Zackay[4] in an extension and verification of the previous work investigated a range of lower alloy high-strength steels. The steels were deformed by compression, before any transformation had occurred, while at temperatures of 600 and 1000 F. Deformations up to 75 per cent were applied by rolling a wedge 5 in. long which tapered from ¼ to ⅛-in. thick. After rolling, martensite was produced by quenching. Tempering temperatures of 500 to 600 F gave steel with tensile strength in excess of 300,000 psi and 6 per cent elongation.

Austenite Deformation

Kula and Dhosi[5] studied the influence of deforming austenite at 1000 and 1550 F in a 4340 steel. Deformation of 72 per cent increased the yield strength of 280,000 psi and the tensile strength of 310,000 psi after tempering at 450 F, improvements of 19 and 13 per cent, respectively.

The only reported work done on property evaluation of warm-forged castings was that of Murphy, Clark and Rostoker,[6] who intensively investigated three non-ferrous alloys. For the 220 aluminum alloy, improvements of 100 per cent in the yield strength were accomplished by cold forging the metal section 40 per cent. Ductility was reduced to 7 per cent but was still judged adequate. For the AZ92 magnesium alloy, forging improved the yield strength 40 per cent with the test bar deformed 20 per cent, and no ductility loss was experienced.

It is apparent from this résumé that no work has been done on the forging of steel castings at temperatures which would lead to strain-induced or modified reactions. The literature cited for wrought steel investigations clearly indicates the possibilities for improvements in the mechanical properties of steel castings by such treatment. The data which follow are extracted from existing research in this area under the sponsorship of the Manufacturing Methods Div. of the Air Materials Command, Wright-Patterson Air Force Base, Contract No. AF 33(600)-36387.

TECHNIQUES AND EXPERIMENTAL METHODS

The mechanical property evaluation has been done on rectangular cross-section test bars sliced from the large block casting shown in Fig. 1. These test bars are uniform in composition, soundness and grain structure. To ensure this quality, the bars were taken only from the central portion of the block casting where end effects were no longer felt, and then were x-rayed to 2 per cent sensitivity at right angles to the plane of the saw cut.

The test bars have been solution treated or austenitized, quenched to isothermal conditions (temperature dependent on alloy composition) and press forged a controlled amount at this temperature by the dies which were heated or cooled accordingly. A view of the heated dies is shown in Figs. 2 and 3.

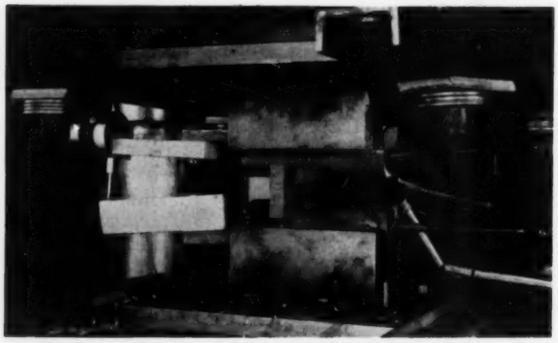

Fig. 2 — Front view of press forging arrangement.

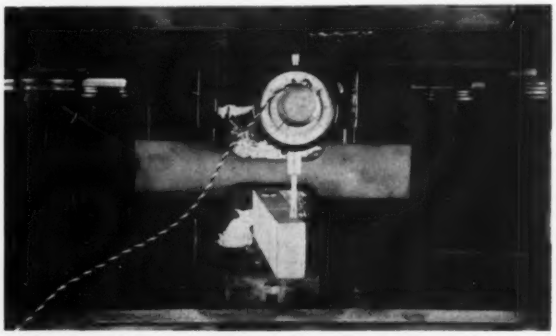

Fig. 3 — Side view of press forging arrangement.

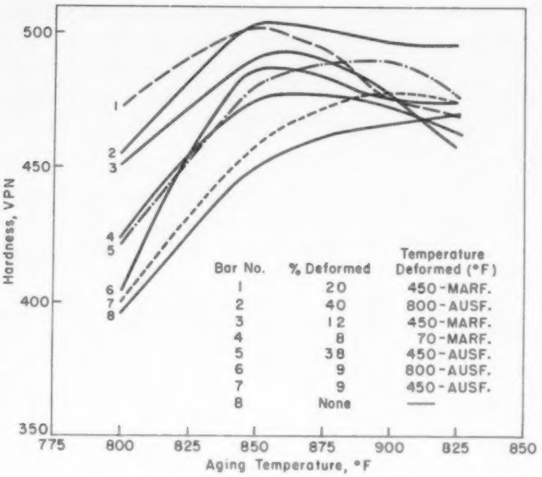

Fig. 4 — Aging reaction of 17-4PH after deforming.

They are then immediately quenched to previously selected temperatures. The time allowed for each of these operations can be critical for certain easily transformed steels. The forging effort was applied only to the two faces of the bar in the reduced gage length.

Work is in progress of three steel compositions representative of three basic families—the AISI 4340 alloy steel, 17-4PH precipitation hardening stainless and CF-8C (347) austenitic stainless. Aging of a 17-4PH steel which had been press forged at three temperatures caused a distinct increase in hardness. In addition to the hardening effect, deformation also caused a shift in the optimum hardening temperature. These results are shown in Fig. 4. That tensile properties were also affected, is shown by the data of such properties vs. deformation in Table 1.

The remarks following summarize the observed effects of press-forging 17-4PH:

a) Press forging at room temperature of a principally martensitic structure results in a marked increase in mechanical properties for relatively small amounts of deformation.
b) By press forging a similar structure, at 450 F, or alternatively press forging an austenitic structure (ausforming), the mechanical properties obtained by room temperature deformation may be approached. However, the approach is at a slower rate, and it must be noted that for the ausforming a combination of lower yield and higher elongation is obtained.
c) Reheating at 800 F and press forging at this temperature results in an embrittled structure. This is analogous to temper embrittlement experienced in other chromium-rich steels.
d) The aging temperatures required to develop the optimum mechanical properties are lowered by press forging prior to aging, as anticipated from the hardness results.

The curves shown in Figs. 5, 6, 7 and 8 graphically repeat this data to show more clearly the rate of approach to optimum values.

TABLE 1 — MECHANICAL PROPERTIES OF 17-4PH STAINLESS STEEL PRESS FORGED AND AGED

Deformation, %	0.2% Yield Stress, psi	UTS, psi	Elong., % 1 in.	Elong., % 2 in.	Aging Temp., F
		Base Properties			
—	158,000	175,000	9	5	925
		Press Forged at Room Temperature			
4.1	193,000	202,000	5.1	2.8	860
5.1	187,000	202,000	4.3	2.4	860
10.0	198,000	208,000	4.5	2.5	860
11.0	194,000	204,000	5.3	2.8	860
		Press Forged at 450 F			
4.2	193,000	205,000	6.5	3.3	860
11.5	197,000	206,000	5.0	3.0	860
15.5	190,000	203,000	4.7	2.5	860
20.0	—	198,000	5.0	2.8	860
11.4	186,000	203,000	6.0	3.8	880
20.0	191,000	202,000	5.7	3.5	880
10.7	182,000	200,000	5.7	3.0	900
23.8	196,000	208,000	5.0	3.0	900
		Ausformed at 450 F			
6.4	170,000	191,000	20.0	10.8	900
12.5	180,000	187,000	10.0	6.3	900
13.2	177,000	190,000	11.0	5.8	900
23.6	181,000	192,000	10.0	6.3	900
23.9	—	192,000	19.2	9.5	900
23.0	184,000	192,000	9.0	4.8	860
39.6	183,000	206,000	9.5	5.7	860
		Ausformed at 800 F			
8.6	182,000	202,000	7.2	3.9	860
18.8	162,000	200,000	5.0	2.5	860
19.5	182,000	200,000	6.2	4.0	860
38.9	184,000	203,000	13.5	7.5	860
39.3	184,000	204,000	18.5	10.0	860

Press Forging Deformation

An 18/8 stainless steel, made to the CF8C specification, was deformed by press forging at three selected temperatures. This treatment was followed by tempering at previously determined optimum temperatures, as selected by hardness studies. Table 2 shows the increase in mechanical properties consequent upon press forging at —80 F room temperature.

The data presented in Table 2 is summarized:

a) The mechanical properties of both the high- and low-carbon stainless steel are significantly improved

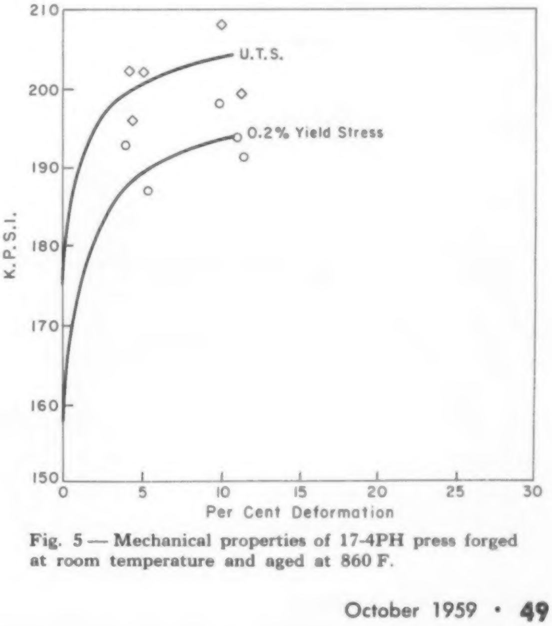

Fig. 5 — Mechanical properties of 17-4PH press forged at room temperature and aged at 860 F.

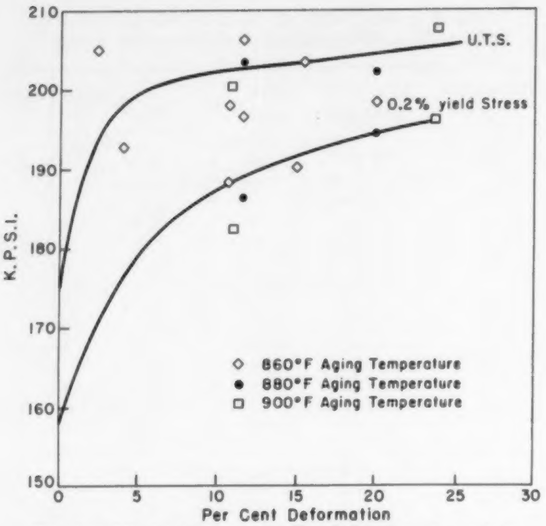

Fig. 6 — Mechanical properties of 17-4PH reheated to 450 F, press forged and aged at various temperatures.

by press forging at all temperatures, but in particular at the sub-zero temperatures. The improvement is related to the amount of martensite produced by the deformation/temperature combination, and to the subsequent working of this low-carbon martensite.

b) The elongations obtained in the low-carbon stainless steel are markedly superior to those seen in the higher carbon stainless steel, although the ultimate tensile strengths do not reach such high values as those of the latter.

The graphs, Figs. 9, 10, 11, 12 and 13, more clearly illustrate the effect on the ultimate tensile and 0.2 per cent yield strength. The various post treatments of bars previously forged at room temperature show no advantage for any of these treatments.

Finally, strengthening by the formation of martensite is not confined to any particular location in the bar cross-section. Photomicrographs, shown in Figs. 14 and 15, indicate that slip plane orientation is more critical than location of the individual grains.

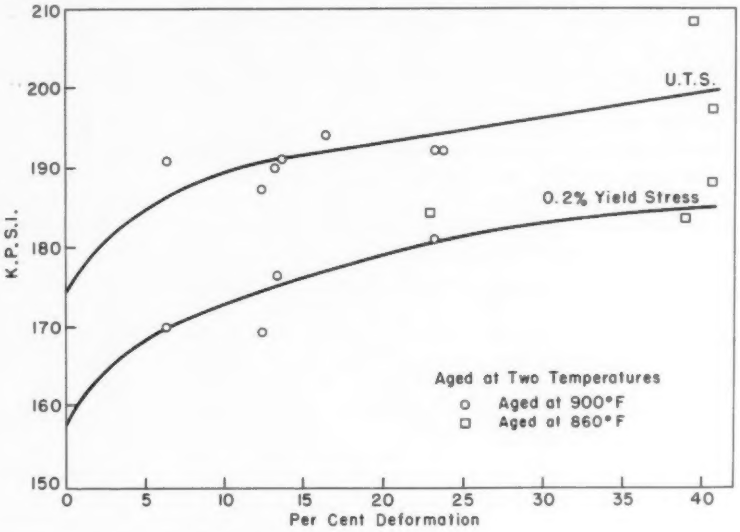

Fig. 7 — Mechanical properties of 17-4PH ausformed at 450 F by press forging.

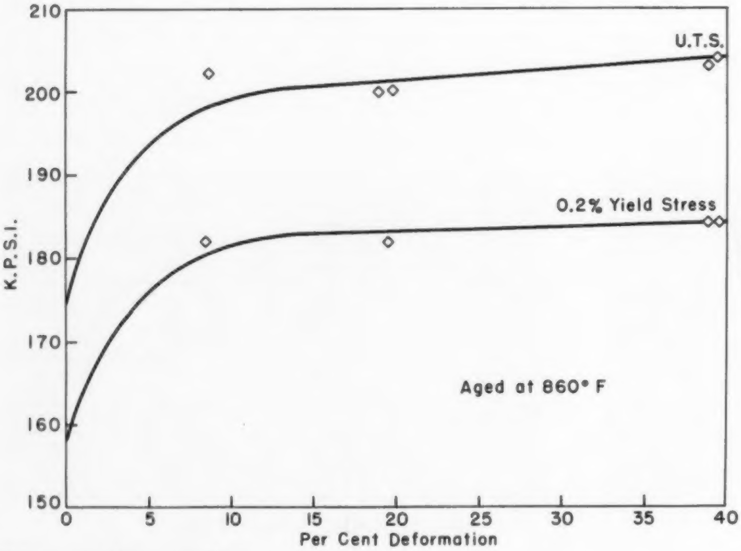

Fig. 8 — Mechanical properties of 17-4PH ausformed at 800 F by press forging.

PROCESS APPLICATION

The conversion of this laboratory duplex process to a useful production method will require the development of more knowledge. The problems fall into two broad categories—namely, those of most concern to the designer of the cast-forged component, and those of most concern to the manufacturer of such a component. As with all methods, there are important points of mutual interest that will demand coordinated effort.

Problems of the Designer of Forged Castings

It is the responsibility of the designer to make a part functional within the space limitations allowable, to provide ways of making the necessary attachments, to know the forces active on the part and to construct a shape which will withstand those forces when constructed from a material with known properties.

In order to use a new material intelligently, it is imperative that the mechanical and physical properties be known and be reproducible. Information currently available for this duplex process is inadequate in both respects, and the present work will fill only

TABLE 2 — MECHANICAL PROPERTIES OF 18/8 STAINLESS STEEL (CF8C) LOW CARBON AND HIGH CARBON, AFTER PRESS FORGING AND TEMPERING

Carbon Content, %	Deformation, %	0.2% Yield Stress, psi	UTS, psi	Elong., % 1 in.	2 in.
		Base Properties*			
0.09	—	32,000	74,500	44	35
0.03	—	30,600	70,200	85	65
		Press Forged at Room Temperature**			
0.09	5	54,000	78,000	26	18
	18	96,500	107,000	11	5.5
	39	129,000	155,000	4	2.5
0.03	5	50,200	79,000	71	50
	17.4	87,600	104,000	46	27
	36.8	114,000	137,000	23	10
		Press Forged at —80 F+			
0.09	7.0	45,200	79,500	33	21
	20.8	144,000	147,000	6	3
0.03	2.5	37,100	71,000	65	43
	17.0	98,500	122,500	40	23
	32.0	162,000	171,000	21	9

* Not tempered.
+ Tempered at 650 F.
** Tempered at 800 F.

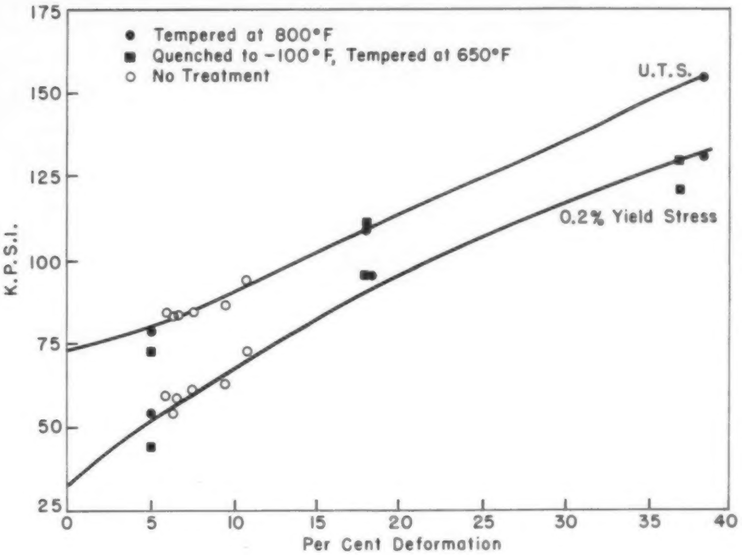

Fig. 9 — Mechanical properties of 18/8 stainless steel CF8C (high carbon) press forged at room temperature.

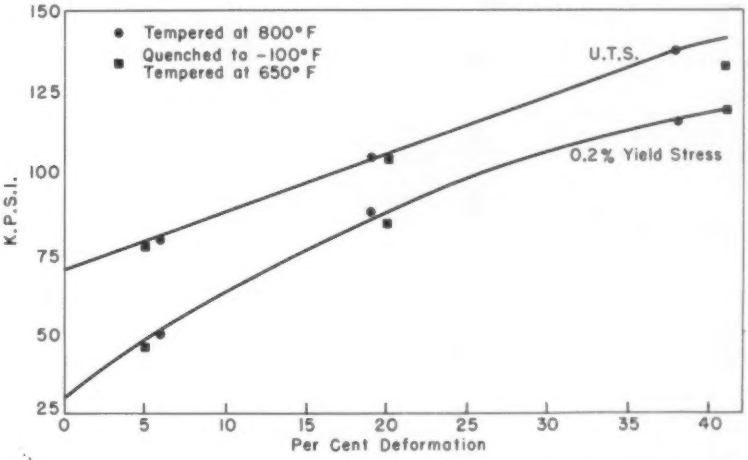

Fig. 10 — Mechanical properties of 18/8 stainless steel CF8C (low carbon) press forged at room temperature.

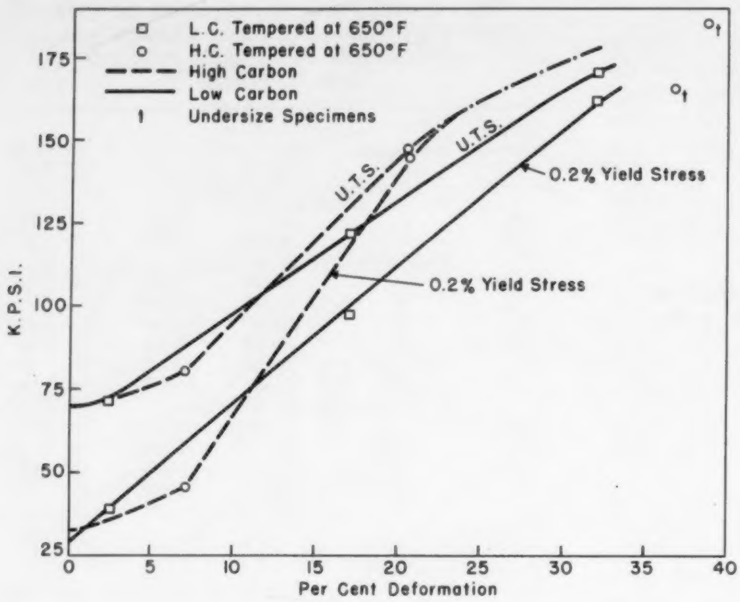

Fig. 11 — Mechanical properties of 18/8 stainless steel CF8C (high and low carbon) press forged at —80 F.

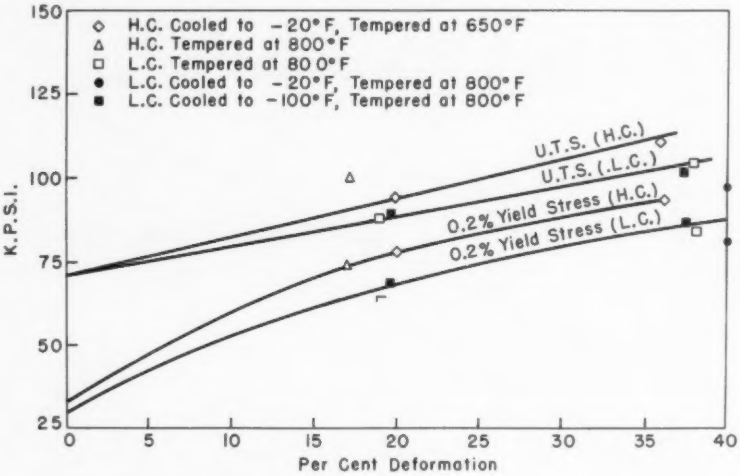

Fig. 12 — Mechanical properties of 18/8 stainless steel CF8C (high and low carbon) press forged at 450 F.

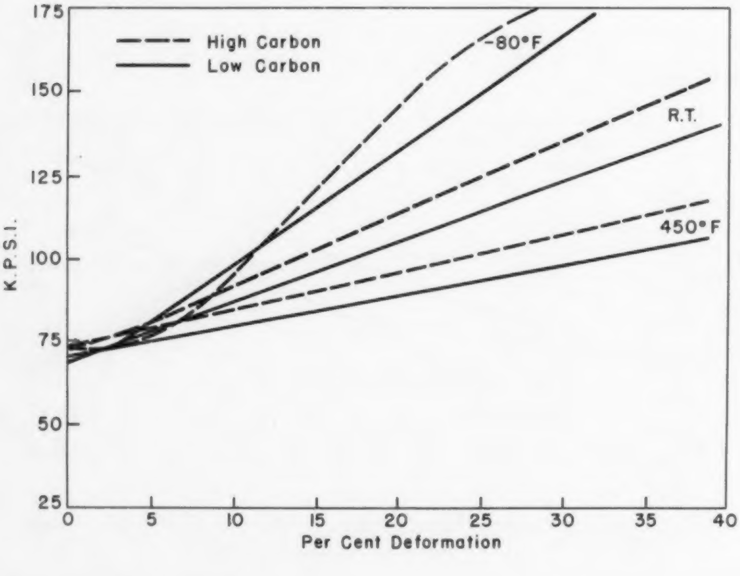

Fig. 13 — Press forging temperature effect upon ultimate tensile strength of 18/8 stainless steel CF8C.

some of the gaps. In spite of this condition, the problems of alloy selection and treatment are susceptible to some rational analysis so that likely candidate metal compositions can be selected for this process and their properties evaluated by testing.

When considering steels, the basic strengthening mechanisms are work hardening, precipitation hardening and martensite or bainite transformation hardening. Of these the latter two are most effective and can be found together in certain alloys. The effects can be additive.

In order to plan a press forging, heat treatment sequence and select an alloy amenable to improvement, the isothermal transformation diagram—or, better yet, the continuous cooling curve—is required. The curves must provide sufficient time to quench the casting to the forging temperature without getting undesirable transformation products. A ferrite nose, past which the casting can be quenched easily, and a pronounced gap between the ferrite and bainite noses is necessary.

The allowable time before transformation begins is barely sufficient to perform the quenching and forging operations in 4340 alloy. Most of the moderately alloyed steels have transformation curves of this general configuration, while the retardation of some high alloys, such as 17-4PH and 18/8 is so great that no isothermal diagram has been determined.

For the low alloy materials the application of strain causes a shift in position of the various boundary lines of the isothermal transformation curve. In general, these changes are toward shorter times and higher temperatures for any reaction. Bhattacharyya and Kehl[7] have illustrated this affect for various steels, including 4340. The start of martensite transformation is also elevated by the application of stress.

Problems in the Manufacture of Forged Castings

The basic configuration produced by the designer is altered to yield the best shape for forging. The problems encountered here are similar to those faced for conventional forgings and include:

1) Provision of forging draft.
2) Avoidance of hollow-sections and undercuts.
3) Estimation of metal flow.
4) Calculation of forging pressures.
5) Allowance for springback.

The choice of forging method probably is one point of divergence from conventional practice. Since the ductility of metal below the recrystallization temperature is much less than for hot forging, slow forging methods would be favored to give the effect of greater ductility. In addition, the dies used in this process may be heated electrically and, in the interest of reasonable heater element life, minimum impact loads are desirable. For these reasons press forging methods are favored over drop forging.

The die design can be troublesome if high die temperatures are required or if high flow stress are encountered. At warm temperatures the flow stress of most steels is more than 20 per cent greater than the 0.2 per cent offset strength, and it increases as the forging deformation increases. This imposes size limitations on a part and calls for high strength, non-deforming dies and high capacity presses. Deformations greater than the ductility level at the deforming temperature should not be attempted.

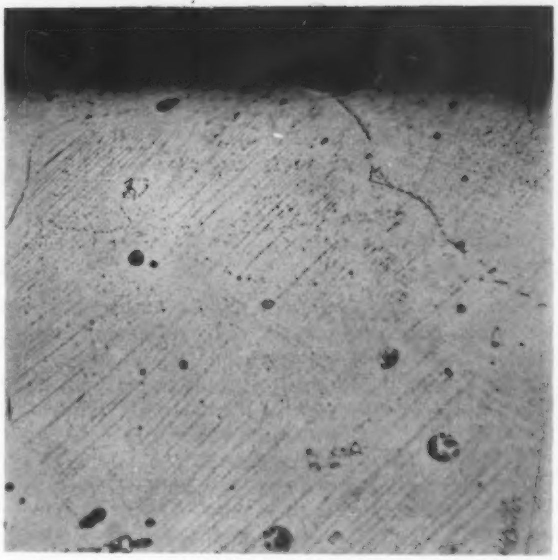

Fig. 14 — Grain orientation effect upon formation of martensite at site adjacent to press forged surface. Kalling's reagent etch. 250×.

Materials to resist deformation, ranging from cobalt-base heat-resistant superalloys to chilled white iron, have been used successfully in their cast form. If the part to be forged has varying metal sections which still require the same percentage deformation, multistage forging may be necessary. This should be avoided if possible.

Good Design

The cast forging blank is designed so that the forging deformation will result in a finished part of the

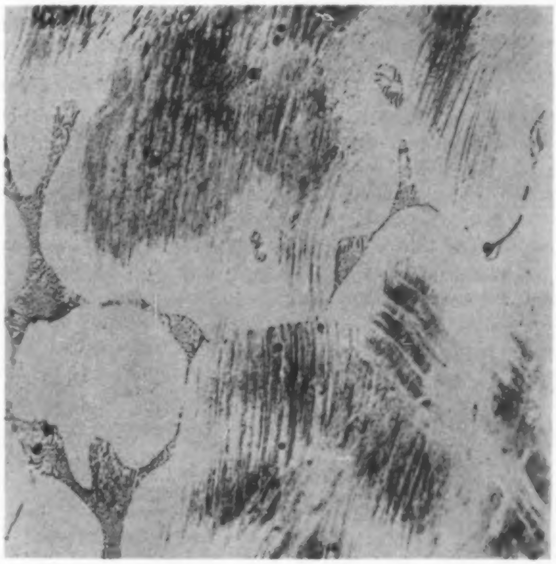

Fig. 15 — Grain orientation effect upon formation of martensite at site in center of press forged section. Kalling's reagent etch. 250×.

correct size and shape. Fortunately, good casting design and good forging design have much in common. These points should be observed when casting the forging blank:

1) Uniformity of metal sections.
2) Easy blending of different sections.
3) Directional solidification.
4) Accessibility of metal masses.
5) Avoidance of stress concentration.
6) Low cost production.

Since the forging process by its nature is more restrictive regarding possible shapes than the casting process, casting of a forging blank should be relatively simple. The most important problems will be the elimination of centerline shrinkage and control of grain size. At the working temperatures employed closure of voids would not be complete, so that the advantages noted by Sims[1] for imperfect castings would not be important.

A reasonably fine-grained casting, free from coring and segregation, will help minimize cracking and non-uniform surface conditions during deforming. The fine-grained structure may possess slightly higher ductilities and does possess better impact resistance, but would be primarily important to minimize segregation, although a higher flow stress will be encountered during deforming.

CONCLUSIONS

Experimental evidence pointing toward worth-while improvements in mechanical properties of castings by press forging at selected temperatures has been presented and discussed. The potential advantages are thought to result because of strain-induced changes in metallurgical structure, principally in the orientation, location and size of martensite, and precipitation hardening nuclei.

Mechanical improvements, when compared to the same composition hardened by heat treatment, where applicable, include higher ultimate tensile strength, yield strength, proof strength and hardness, without the same degree of ductility loss.

The directionality of properties, as customarily encountered in forgings made from billet stock, would be minimized by the cast preform.

The closure of defects in the casting would probably constitute a minor gain only.

Localized application of forging stress can be used to strengthen specific problem areas. It is conceivable that such forging could be done with simple flat dies.

Die material requirements call for specific compositions if working with heated dies or high flow stress cast-forged parts. Casting of such dies is feasible and practicable.

Limitations on design are more akin to forgings than castings, so that subsequent machining often would be indicated. Use of uniform sections and simple shapes is in the interest of process economy.

ACKNOWLEDGMENT

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CONTINUOUS CARBON INJECTION

By J. E. Wilson and R. C. Shnay

ABSTRACT

The total carbon content of gray iron melted in an acid cupola depends on a multitude of factors, by far the most important being the carbon content of the metallic charge. The pig iron usually has a higher carbon content than any other component of the charges, so most foundries depend primarily on changes to the per cent pig iron to adjust the final carbon content. Since this material is the most expensive component, and may be in short supply during periods of national emergency, there is an obvious need for an alternative method of controlling final carbon content particularly at the higher levels.

Many types of gray iron castings require a high carbon content to ensure that sufficient fluidity is available to produce a sound casting. In other cases, a high carbon content is necessary to produce the required properties. In all cases carbon control is essential, since this element has the greatest effect on mechanical properties and machinability.

This project was divided into four phases:

1) To obtain or devise dispensing equipment for the process.
2) To solve the problem of blockages and lance failures.
3) To determine practical methods of control.
4) To establish plant operating procedures for the process.

While the principles are simple and the basic requirements were readily established, many small points had to be cleared up before uniform and reliable operation could be assured.

INTRODUCTION

Control of carbon content in an acid cupola by methods, other than adjustments to the pig iron charge, can be divided into two general categories. Material such as carbon blocks, graphite electrodes, lump silicon and calcium carbide have been added to the coke bed. However, consistent results were not obtained.[1] Ladle additions of graphite powder have been found to produce an inoculating effect, but no more than 0.10 per cent to 0.15 per cent carbon could be recovered.[2] The advantages of ladle treatment are the inoculating effect and also the speed with which compositional adjustments can be made.

In a basic cupola operation satisfactory carbon control can be achieved by adjustments to the blast or slag composition. High carbon contents achieved in this way are obtained at the expense of a decrease in melting rate. Although the problem of carbon control is different in a basic cupola than in an acid operation, there is still a need for a method of obtaining high carbon contents consistently with no decrease in melting rate.

The most successful solution to this problem is the carbon injection process. This was first described by Spangler and Schneidewind.[1] These authors reported carbon increases of up to 1.9 per cent with recovery efficiences ranging from 50 per cent to 100 per cent depending on the injected material. A high degree of reproducibility was obtained and data were presented to show that gray iron treated in this manner showed "a greater degree of uniformity and predictability of properties." The authors concluded that carbon injection produced the same effect on mechanical properties as an inoculation treatment.

Although Spangler and Schneidewind were primarily concerned with the metallurgical advantages of carbon injection, there is also a decided economic advantage in that at least a part of the pig iron charge can be replaced by iron or steel scrap. The resulting metal is at least equivalent if not higher in quality than if it had been produced by entirely orthodox means.

Injection Process

In the carbon injection process, fine particles of graphite or other carbonaceous material are carried by a stream of relatively inert gas, such as nitrogen, through a graphite tube or lance immersed in the liquid metal. The carbon particles are delivered to a point below the surface of the metal where they are readily dissolved, and in this way high recoveries are obtained. The equipment and general method are similar to those used for desulfurizing by the injection of calcium carbide, lime or aluminum magnesium alloys.

Although the carbon injection process was first reported publicly by Spangler and Schneidewind,[1] the technical feasibility of this process was independently established by J. E. Rehder in 1952. Trials then showed the technical possibilities and a patent search was made preparatory for patent application. However, patent attorney opinion was that while injection of carbon into cast iron was novel, much older patents dealing with carburizing liquid steel made it

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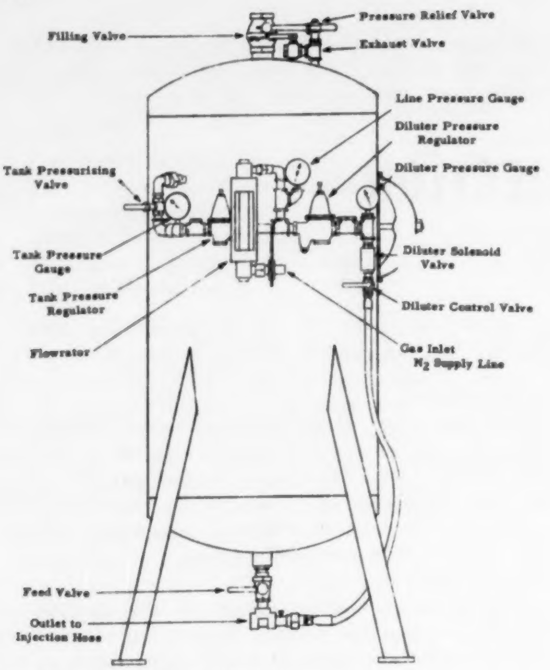


Fig. 1 — Details of injector.

doubtful that a patent could be obtained or defended if attacked.

Because of pressure of other work further development was slow, but in 1954 preliminary plant tests were carried out by A. L. Cooper and P. Biron of National Iron Div., Canada Iron Foundries Ltd. to establish carbon injection on a continuous basis. These tests were carried out in addition to regular production duties and progress was slow. After about three months the work was suspended partly due to the pressure of regular duties, but also because of the difficulty in maintaining uniform feed rates and the problem of rapid lance erosion.

The Research and Development Div. was organized in 1957, and the work on carbon injection was resumed, although a United States company[3] had been granted a U.S. patent on carbon injection of cast iron.

The experience of the previous investigators, and an examination of the conditions necessary for metallurgical and economical efficiency, led to the subdivision of this project into four distinct phases.

1) To obtain, or if necessary devise, dispensing equipment capable of stable operation at feed rates of 2 to 3 lb/min.
2) To solve the problem of lance failures and blockages and limit lance consumption to a gradual and continuous process.
3) To determine practical methods of control so that the final carbon content of the metal could be held within suitable narrow limits despite fluctuations in the melting rate and the composition of the metal leaving the tap hole.
4) To establish a procedure for operating the carbon injection process in the plant.

The first phase of the project, to find suitable dispensing equipment, was carried out at National Iron Div., and a start was also made on finding a solution to the problem of lance failure and blockage. In Aug. 1957, the program was transferred to the Delavaud Shop in the Trois Rivieres plant. While trying to determine a suitable test setup at Trois Rivieres a solution was found to the lance problem. The test program then proceeded to the third phase and control procedures were established by Dec. 1957.

Operational equipment was purchased and installed during April 1958. Operating procedures were then developed and the plant personnel were trained to use the equipment. The equipment and process were formally handed over to the plant staff in May 1958, and carbon injection has been a regular part of the operation since that date.

EQUIPMENT AND MATERIALS

Dispensing Equipment

Basically the dispensing equipment is simple, and consists of a pressure vessel, mixing assembly and a delivery system. At the low feed rates of 2 to 3 lb/min used in this investigation, the net pressure in the delivery system is low, since the metal itself exerts a back pressure due to the ferrostatic head which increases with immersion depth. This becomes an important factor when low feed rates are used since the net pressure may not be any more than 1 psi.

Because of this low pressure, any line obstruction due to surface roughness, sharp bends in the hose or changes in section at the junction of a fitting and the hose, can cause blockage and stop the flow of graphite. The low pressures necessary for these feed rates introduce additional problems in the design of gauges and regulators.

After some experimentation an American company was able to supply suitable equipment. Diagrams of this equipment are shown in Fig. 1.

Injection Lances

The injection lances are graphite "fluxing tubes" with an outer diameter of 2 in., an inner diameter of ½-in. and length of 9 ft. The inner diameter is threaded at one end to enable connection with the hose from the dispenser. A fitting is inserted at the end of the hose leading from the dispenser so that it can be threaded into the lance. A suitable fixture was mounted in the well or forehearth to hold the lance in position.

Graphite

Electric furnace graphite was used which had the following approximate sieve analysis:

Retained on 20 mesh screen, %	5
Retained on 65 mesh screen, %	80
Retained on 100 mesh screen, %	15

Later tests showed that equivalent results were obtained with an alternative electric furnace graphite having the following approximate sieve analysis:

Retained on 10 mesh screen, %	5
Retained on 65 mesh screen, %	80
Retained on 100 mesh screen, %	15

The particle size and particle size distribution were found to be quite critical in obtaining satisfactory

flow. Coarser particles tended to give unstable operation with wide fluctuations in feed rate while finer particles did not flow properly and produced blockages in the system.

The nitrogen used in these tests was the dry oil-pumped grade.

TESTS AT NATIONAL IRON DIVISION

The major object of this series of tests was to determine whether the dispenser was capable of continuous operation at a feed rate of 2 to 3 lb of graphite/min. A secondary objective was to find a solution to the problem of lance erosion and blockage.

The dispenser was placed on a platform scale located on the charging floor to one side and slightly forward of the cupola. The graphite delivery hose was lowered through a hole in the charging floor directly in front of the cupola so that the hose was suspended over the front slagging spout. Injection was carried out in an enlarged well located forward of the slag dam. The inside dimensions of this well were approximately 20 in. x 20 in. x 20 in. A hood was designed to fit over the well, and a hole was cut in the hood to accommodate the lance. A simple hoist consisting of a ratchet winch pulley and cable was installed to raise and lower the lance. A sketch of the complete setup is shown in Fig. 3.

The first two tests were carried out merely to check the installation, and the charge was chosen to obtain a total carbon content of about 3.5 per cent at the tap hole. Carbon pickup was about 0.17 per cent in the first test and 0.39 per cent in the second. The next test was a dry run for purposes of calibration. The graphite was discharged into a bucket. Different settings were used, and the amount of graphite discharged/min was determined for each setting. This procedure cannot lead to a complete calibration since the pressure due to the head of liquid metal varies with immersion depth and can only be estimated in a dry run, but it did help to establish suitable settings for the operation.

During subsequent tests the pig iron was reduced by 50 per cent, and final carbon contents were held in the range of 3.65 per cent to 3.80 per cent.

These tests showed that the dispensing equipment could be operated at feed rates as low as 1.75 lb/min for an indefinite period. The only interruptions were due to lance erosion and blockages, which occurred at 15 to 20 min intervals.

Lance Tests

Coatings of refractory cement and sodium silicate were tested to see if they could improve lance life. In addition, tests were carried out with the tapered lances. None of these measures produced any significant improvement. Alternative lance materials were also investigated and discussed with representatives of two refractories companies, but none were found that warranted testing.

The appearance of the used lances suggested that failures were caused by a cavitation or pitting type of erosion, which led to the formation of pinholes. When the pinholes extended through the wall, the gas pressure was released, but at this stage the holes were still too small to allow passage of the graphite.

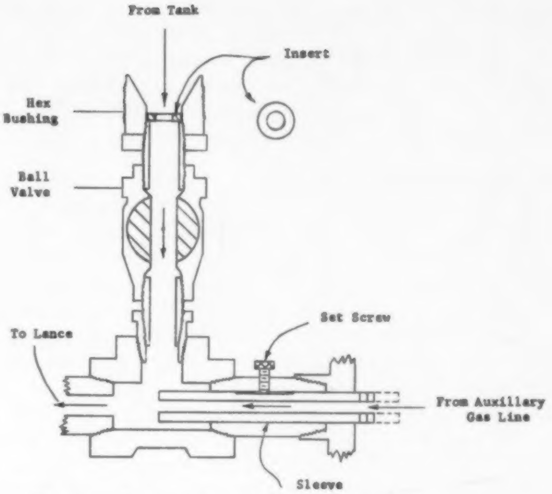


Fig. 2 — Cross-section of mixing assembly.

The graphite then accumulated in the lance since there was no pressure to force it through, and the subsequent blockage led to failure of the lance. The most likely cause of this type of erosion was the turbulence of the liquid metal along the walls of the lance.

The above hypothesis was verified by leaving a lance immersed in the well for several hours with no flow of nitrogen or graphite. This exposure resulted in only a minor amount of lance consumption due to a smooth and continuous type of attack.

The next step should have been to do tests with varying rates of nitrogen flow to find the minimum flow rate which would still allow satisfactory injection. Unfortunately, the equipment was being used near the lower limit of nitrogen flow rate and the allowable range was too narrow for a conclusive test.

Drop tests and metallographic examination were

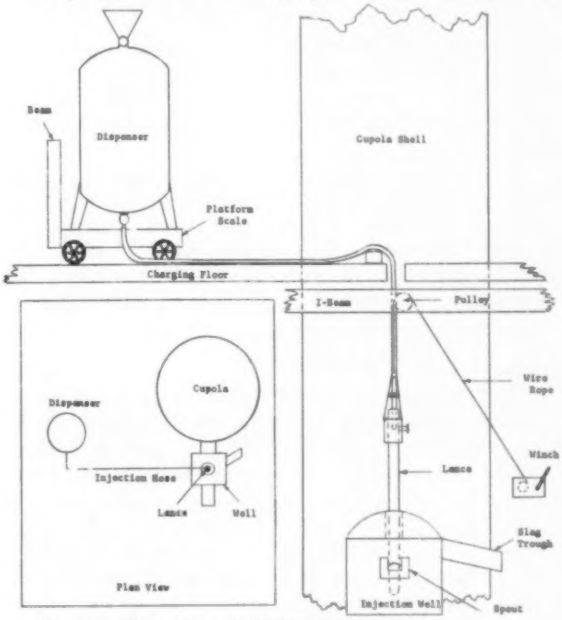


Fig. 3 — Test setup at National Iron Div.

done on pipe produced during the carbon injection tests. The level of carbon content of the injected metal was considerably higher than normally produced so that it was impossible to determine whether the observed improvements were due to the injection process as such, or merely the higher carbon content.

Carbon Recovery

The tap hole, spout and well were arranged in such a way that it was impossible to obtain metal samples before injection, therefore, accurate figures for carbon recovery could not be obtained. Nevertheless, some estimates were obtained by taking samples immediately before the injection tests started. The results indicated a carbon recovery of about 80 per cent.

Tests could not be carried out every day during this period because of production requirements. On some occasions the equipment was used successfully by the plant staff to overcome temporary operating difficulties. The procedure in these cases was to station a man at the injection well to inspect and manipulate the lance. At first two lances were used changing after every blockage. A new lance was inserted and in the meantime the blocked portion of the first lance was removed so that it could be put back in service after the second lance failed or became blocked.

Another method used was to break off the defective portion of the lance by striking it against the bottom or side of the well. Neither of these procedures could be considered practical for a permanent operation.

TESTS AT TROIS RIVIERES

The first objective of these tests was to solve the problem of lance failures and blockages. Once this was done, the next step was to determine suitable dispenser settings for a consistent carbon increase from 3.30 per cent to 3.65 per cent. Before any of this work could be done, it was necessary to establish a suitable arrangement for the dispenser and lance so that satisfactory tests could be performed without undue disruption of the plant operation. A well had not been installed in the spout of either cupola in this shop so that carbon injection had to be done in a forehearth.

The solution to the lance problem became apparent while establishing the injection setup. After solving the lance problem it was possible to inject continuously with little interruption for an indefinite period. Methods were then developed to control the carbon content despite fluctuations in the composition at the spout and variations in the melting rate.

Lance Problem Solution

The Delavaud Shop at Trois Rivieres is equipped with two cupolas which are used on alternate shifts. A tilting drum type of forehearth is used to collect the iron from each cupola. The north cupola was used for the first test in this plant with the lance inserted in a vertical position through forehearth cover. This arrangement was similar to that used in the injection well at National Iron Div., with the exception that a chain-operated trolley crane was available to raise and lower the lance.

Because the forehearth must be tilted to transfer iron to the ladle, it was necessary to cut a slot across the forehearth cover to avoid disturbing the lance. The results of this test were approximately the same as at National Iron Div.

Slant Immersion

The south cupola had to be used for the second test, and it was found that the hose was too short to immerse the lance in a vertical position. At this stage it became apparent that the problem of lance failures and blockages might be solved by immersing the lance at an angle of about 45 degrees. A test proved this was indeed the case and excellent results were obtained. The reasoning that led to this solution is illustrated by the schematic diagram shown in Fig. 4. Figure 5 shows one lance after vertical immersion and another after slant immersion.

At first the slant immersion was obtained by suspending the lance from one end, the other end floating below the surface of the metal in the forehearth. This procedure was not satisfactory and a fixture was welded to the end plate of the forehearth which held the lance in the correct position at an angle of 45 degrees. Some mechanical troubles were experienced with this at first, but were overcome in later tests. Figure 6 shows the final design of the lance fixture, and Fig. 7 shows the lance and fixture in service.

Lance consumption with slant immersion averaged about 10 in./hr, as compared to 24 in./hr with vertical immersion. This represents a savings of approximately 9 cents per ton, but the continuity of operation resulting from slant immersion is of far greater importance.

Operating Problems

Many operating problems, mainly of a minor nature, were encountered during these tests. Methods to overcome these problems were devised and described in operating instructions issued to the plant.

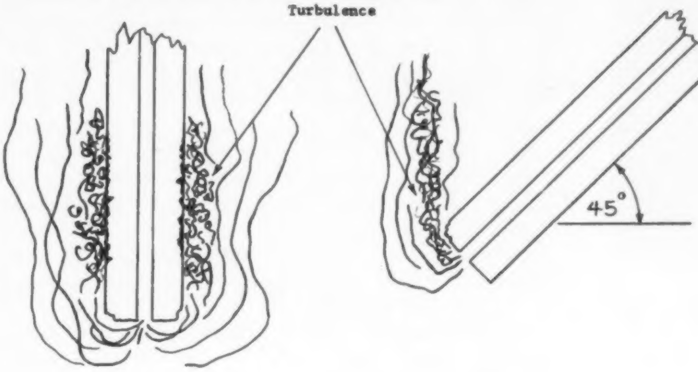
Moisture Conditions. Moisture entering the dispenser is absorbed by the graphite and results in blockages at or near the feed valve. Initially the dispenser was located between the two cupolas slightly above the level of their wells. The heat from the cupola and the spray from its shell cooling system led to considerable difficulty with wet graphite due to condensation and also due to spray from the cooling water entering the dispenser during filling. The dispenser was then moved to the charing floor.

Even in this location, there was still occasional condensation inside the dispenser, particularly during cold weather. Methods were developed to blow out the moisture so that blockages did not occur.

Hose and Fittings. It was found that ordinary rubber hose could not be used to carry the graphite from the dispenser to the lance. The rough inner surface and sharp bends led to blockages during service. Fittings had to be specially machined to ensure that there were no lips on which the graphite could build up since such accumulations also led to blockages.

Regulators. The regulators furnished with the dispenser were found to deteriorate quickly due to the

Fig. 4 — (below) — Schematic diagram illustrating solution to the lance erosion problem. Left view shows vertical immersion; right view shows slant immersion.



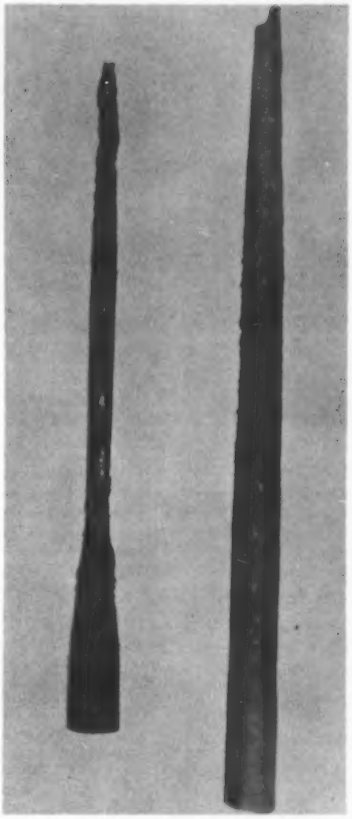


Fig. 5 — (right) — Left view shows erosion after vertical immersion; right view shows erosion after slant immersion at approx. 45 degree angle for the same amount of immersion time.

abrasion of the rubber valve cones by the graphite. Several other types of regulators were tried and a more suitable type was specified.

Disc Insert — Aperture Size. Initial experiments were carried out with a 1/4-in. aperture. However, it was found that 3/16-in. aperture led to a more stable operation.

Position of the Diluter Sleeve. The position of the diluter sleeve was found to be critical. If it is advanced beyond the critical position the graphite builds up around the sleeve and the feed rate is limited to the amount of graphite picked up by the nitrogen from the sleeve opening. If the diluter sleeve is withdrawn from the critical position, the venturi effect is lost and the graphite does not flow into the hose. The optimum position of the tip of the diluter sleeve was found to be located at the center line of the feed valve piping or slightly ahead of it.

CARBON CONTROL

For a given initial carbon content the control of final carbon depends on the following quantities:

a) *Feed Rate.* The weight of graphite powder dispensed by the equipment per min.
b) *Carbon Recovery.* The ratio of the weight of injected carbon dissolved in the metal to the weight of graphite injected, expressed as a percentage.

These quantities are affected by various operational factors, some of which affect more than one quantity.

The feed rate depends primarily on the tank pressure and flowrator settings. At any given values of these settings, the feed rate varies with the length of hose, the difference in elevation between the dispenser and the forehearth and finally the immersion depth. Because of the back-pressure due to the ferrostatic head (height of metal above the bottom tip of the lance), the net pressure in the hose and lance decreases with increasing immersion depth and leads to a decrease in feed rate. The length of hose and the difference in elevation are determined when setting up the equipment and are usually left unchanged.

Carbon recovery depends on the per cent carbon in the powder, the immersion depth and the chemical analysis of the metal before treatment. The carbon content of the graphite powder used in these tests was about 99 per cent so that this factor could be neglected. With increasing immersion depth the graphite has a greater opportunity to dissolve in the metal. This results in increased recovery and tends to compensate for the loss in feed rate caused by the increased head of metal.

Carbon Content Variation

The fluctuations in metal temperature at the forehearth were not serious enough to cause any appreciable variation in carbon recovery. Changes in

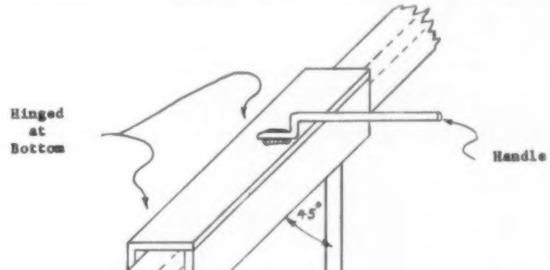


Fig. 6 — Final design of lance fixture.

Fig. 7 — Lance and fixtures in service.

carbon content were the major variations in the chemical composition of the metal before injection. The per cent carbon varied as much as 0.30 per cent, but the increased recovery rate at lower carbon levels tended to even out these fluctuations to give self-regulation.

The actual carbon pickup depends on the feed rate and carbon recovery. Therefore the major operating factor that affects carbon pickup is the immersion depth, which acts on both components. It was found that an average immersion depth of 18 in., with a maximum variation of ± 4 in., resulted in quite uniform values for carbon pickup and good control of the final carbon content.

The best method of maintaining this control of the final carbon content is of course chemical analysis. However, in most plants the results from the analytical laboratory usually arrive too late for effective action. Chill and fluidity tests taken every 15 min, although affected to a lesser degree by factors other than total carbon content, were found adequate for short term control if backed up by regular chemical analyses taken at least once each hr.

Carbon injection at the low feed rates used in these tests is usually accompanied by higher carbon recoveries than when a high feed rate is used. The geometry of the forehearth may also be important since it affects the degree of mixing. However, these two factors are difficult to assess and are not usually changed to any appreciable extent in any given operation.

Carbon Recovery

Long term tests were not carried out to obtain accurate estimates of carbon recovery, although this was determined at frequent intervals during the course of the investigation. With slant immersion the carbon recovery ranged from about 82 per cent to about 95 per cent. After suitable procedures were established the carbon pickup averaged about 0.30 per cent to 0.40 per cent at a feed rate of 2.75 lb/min.

The melting rate was changed frequently during these tests by adjustments to the blast volume. This was necessitated by conditions in the shop, but simple methods were developed to adjust the carbon injection process accordingly. These consisted of small changes in the nitrogen flow rate and/or adjustments to the tank pressure. With the prevailing conditions in this shop each change of ¼ psi in the tank pressure compensates for a change of about 5 per cent to 7 per cent in the melting rate.

Good control of carbon content has been achieved during regular plant operation with carbon injection. The average variation of carbon contents for 20 successive 8 hr shifts was 0.18 per cent, and experience since has shown that carbon content control is now consistently better than before, due to the self-regulating action.

TABLE 1 — STATEMENT OF TYPICAL CUPOLA OPERATION COSTS BEFORE AND AFTER CARBON INJECTION*

	Before Carbon Injection		After Carbon Injection	
	Tons Charged	Total Cost	Tons Charged	Total Cost
Pig iron, $64/net ton	50.0	$3200	15.0	$ 960
Scrap iron, $40/net ton	49.4	1976	84.1	3364
Ferrosilicon, $150/net ton	0.6	90	1.2	185
Nitrogen, $1.30/100 ft^3				18
Graphite powder, $250/net ton				109
Injection lances, $14 ea.				14
	100	$5266	100	$4650

*Acid Cupola Melting at 20 tons/hr.

DISCUSSION

It has been established by other research workers, namely Spangler and Schneidewind,[1] that this process has an inoculating effect which tends to increase the strength of the final product. Improvements in properties could not be definitely verified in these tests since the final carbon content is now at a considerably higher level than it used to be. This move to higher carbon contents was made to improve the quality of the product. Regardless of inoculating effect, a better product is now being made at a lower cost.

At present the limiting factor in application of carbon injection is the increase in sulfur content as the pig iron charge is decreased. Plans are now underway for simultaneous desulfurization and carbon injection which will increase the savings with no decrease in quality.

ECONOMIC CONSIDERATIONS

A typical breakdown of costs is presented in Table 1.

A saving of $6.16/net ton charged is realized, and the final carbon content would be the same at about 3.60 per cent to 3.70 per cent.

With simultaneous desulfurization the pig iron could probably be cut to 10 per cent and the net savings would then be about $6.60/net ton of metal charged. Further savings could be obtained by developing methods to ensure fuller utilization of the lances and also methods to use a cheaper gas such as compressed air, but these could only produce minor savings in relation to those expected from desulfurization.

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CAST AND WROUGHT ALLOY STEELS

elevated temperature properties

By R. K. Buhr and W. A. Morgan

ABSTRACT

The cast and wrought properties at room and elevated temperatures are reported for two known and two new low alloy high strength steels. Three of the steels display secondary hardening, and the mechanism involved in this phenomenon was investigated.

The castings are shown to possess many desirable properties over their wrought counterpart, especially when used at elevated temperatures where the differences in mechanical properties become quite small. In the unnotched condition, longitudinal fatigue properties are superior to those found in castings, but in the notched condition the cast and longitudinal fatigue properties are nearly identical.

Secondary hardening was investigated using electron microscopy and electrolytic carbide extraction techniques. These tests verify that secondary hardening is due to the precipitation of fine alloy carbides.

INTRODUCTION

Recently great interest has been shown in the properties of low alloy alloy steels for use at temperatures up to 1100 F (590 C). The most useful alloys exhibit secondary hardening on tempering the quenched alloy. These steels can be tempered at much higher temperatures than the standard A.I.S.I. 4340 type steels and still have equivalent hardnesses, and it has been claimed that more complete stress relief is thus obtained in a cast or wrought part.

A large amount of information has been published on the properties of the wrought steels at elevated temperatures, but the cast steels have not been investigated so extensively. This paper presents the results of some initial work being carried out on the room and elevated temperature mechanical properties of some low alloy steels in the cast condition. The properties of these same compositions in the wrought condition have also been determined so that comparisons may be made.

In order to obtain a more complete understanding of the relationship of the properties of these cast steels to their microstructure and heat treatment, a brief account is given of some experimental work on the electron microscopy of these steels after tempering at different temperatures.

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EXPERIMENTAL PROCEDURE

Melting and Casting

The heats were made in a basic-lined direct arc electric furnace of 550 lb capacity. Double slag procedure was employed, and all heats were deoxidized in the ladle with 2 lb/ton of aluminum. Half of each heat was poured into ingots, while the remainder was poured into a standard four-leg keelblock casting.

Chemical Composition

The analyses of the steels used in this investigation are shown in Table 1.

Forging and Rolling

The ingots were cropped and then forged from the 5½-in. ingot diameter to a 4½-in. square billet, and then to a 2¼-in. thick slab. This slab was subsequently rolled to a 1-in. thick plate. The reduction obtained by this hot working was approximately 4 to 1.

Machining

Tensile, impact and fatigue bars were rough machined from either the keelblock legs or the 1-in. plate (longitudinal direction). At least 0.030 in. of stock was left on the diameter of the tensile and fatigue bars, while the Charpy impact bars were left unnotched. The bars were heat treated, and then finish machined to the final dimensions. Drawings of the Krouse fatigue bars and the tensile test bar used

TABLE 1 – ANALYSES OF STEELS USED

Element, %	Heat A	F	H	J
C	0.38	0.39	0.38	0.38
Mn	0.61	0.65	0.47	1.12
Si	0.19	0.44	0.78	0.22
S	0.019	0.014	0.019	0.019
P	0.010	0.008	0.012	0.012
Cr	0.95	1.34	4.97	2.04
Ni	1.68	–	–	–
Mo	0.36	0.47	0.88	1.71
V	–	0.32	0.57	0.15

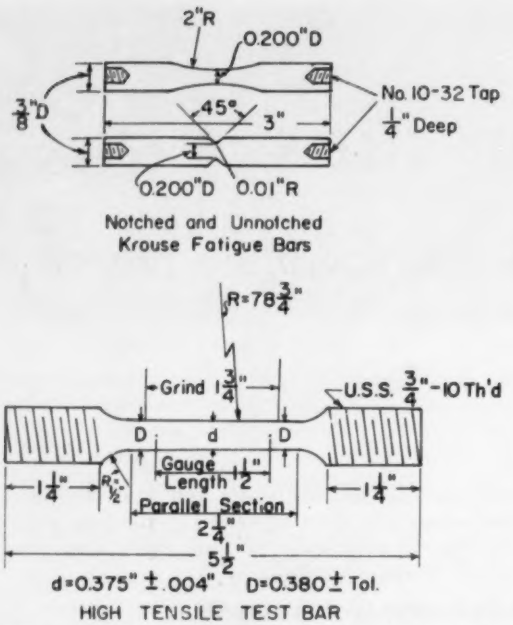


Fig. 1 — Drawings of fatigue bars and tensile test bar used.

are shown in Fig. 1. A standard Charpy V notch impact bar was used for the impact tests.

Jominy hardenability tests were performed on standard 1-in. diameter specimens, while the dilatometer specimen was 5/16-in. diameter and 2.570 in. long.

Heat Treatment

In order to determine the optimum tempering temperature for heats F, H and J, 1x1x2 in. samples from each of these heats were austenitized at either 1950 F (1060 C) (heats F and J) or 1900 F (1035 C) (heat H), and either air cooled (heats H and J) or oil quenched (heat F), and then tempered at different temperatures. The hardness tempering temperature curves obtained are shown in Fig. 2.

The rough machined test bars were heat treated as follows:

Heat A –	Normalized	1650 F	
	Reheated to	1475 F	Oil quenched
	Drawn at	750 F	5 hr – air cool
	Redrawn at	750 F	2 hr – air cool

Heat F –	Normalized	1700 F	
	Reheated to	1950 F	Oil quenched
	Drawn at	1150 F	5 hr – air cool
	Redrawn at	1150 F	2 hr – air cool
Heat H –	Normalized	1700 F	
	Reheated to	1900 F	Air cool
	Drawn at	1050 F	5 hr – air cool
	Redrawn at	1050 F	2 hr – air cool
Heat J –	Normalized	1700 F	
	Reheated to	1950 F	Air cool
	Drawn at	1125 F	5 hr – air cool
	Redrawn at	1125 F	2 hr – air cool

Jominy hardenability bars were austenitized at the same temperatures as those used in the heat treatment and quenched in a jet of water as in the standard procedure. The results are plotted in Fig. 3.

Dilatometer curves were obtained for each heat at heating rates of 150 C (302 F) per hr along with cooling rates of 150 C (302 F) per hr and 40 C (104 F) per hr. The dilatometer used was of the recording type with an expected accuracy of ± 2 C.

MECHANICAL TEST RESULTS

The tensile results both at room and elevated temperatures are shown in Table 2. Charpy V notch impact results at room temperature and at –40 F are listed in Table 3. Table 4 shows the endurance limit for the four steels in the cast and wrought condition for both notched and unnotched bars.

The critical points obtained from the dilatometer curves are given in Table 5.

The Shepherd fracture grain size of the steels were estimated by four different observers and are reported as averages in Table 6. There was close agreement in the individual estimations.

DISCUSSION

The purpose of this paper is to present and compare some of the room and elevated temperature properties of several alloy steels in the cast and wrought condition, and to explain briefly the mechanism of their strengthening.

Hardness-Tempering Temperature Curves

The resistance to tempering of both cast and wrought alloys was similar. Steel *H* gave the highest hardness on tempering at 1000 F (540 C), but at 1100 F (590 C) and 1200 F (650 C) steels *F*, *H* and *J* differed by only about five points Rockwell C. For

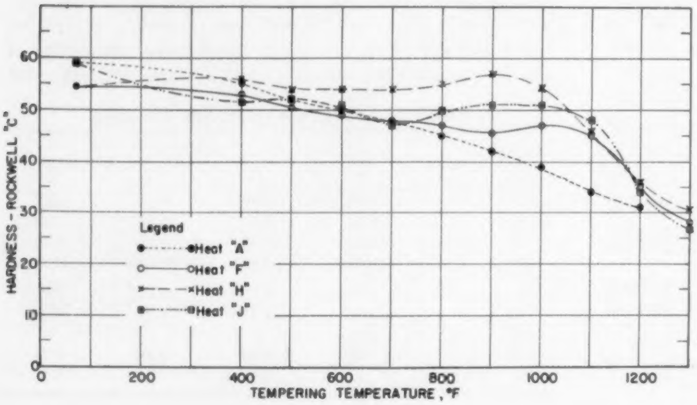


Fig. 2 — Hardness-tempering-temperature curves for the four heats investigated.

Fig. 3 — Jominy hardenability curves for heats *A, F, H* and *J*.

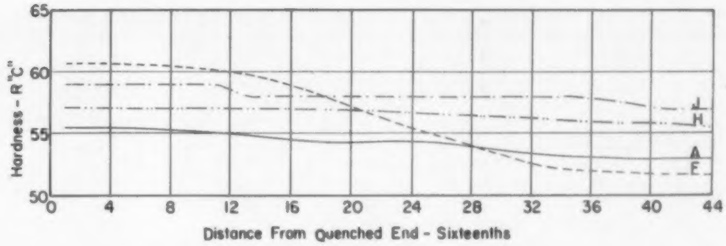


TABLE 2 — ROOM AND ELEVATED TENSILE PROPERTIES OF HEATS A, F, H AND J

Heat	Test Temp. F	U.T.S. Kpsi Cast	U.T.S. Kpsi Wrought	0.2% Proof Stress Cast	0.2% Proof Stress Wrought	Elongation, % Cast	Elongation, % Wrought	R. A., % Cast	R. A., % Wrought
A	70	213.1	215.1	202.0	205.4	5.65	10.0	19.6	41.85
	700	178.3	176.8	156.2	154.4	10.65	15.65	41.05	62.9
	1000	104.65	104.9	86.2	86.6	17.0	20.3	53.1	63.8
F	70	183.0	185.15	164.3	165.65	6.35	12.6	10.8	36.85
	1000	125.3	129.1	108.9	112.8	16.35	16.65	53.55	60.6
	1100	108.75	112.5	93.1	94.2	16.35	15.35	55.6	46.75
H	70	236.5	246.15	205.5	207.75	1.6	9.3	3.6	27.7
	1000	167.6	170.5	140.45	136.85	6.35	16.35	11.15	51.25
	1100	142.25	139.95	112.75	107.2	11.3	19.3	17.4	52.7
J	70	207.1	206.85	187.2	187.1	3.65	8.0	5.5	17.4
	1000	136.8	140.25	119.1	120.8	11.3	12.55	23.4	32.1
	1100	116.2	112.55	96.95	95.75	15.0	18.0	30.25	43.1

resistance to softening at temperatures in the range 1100-1200 F (590-650 C), steels *F, H* and *J* are similar, and all are superior to steel *A*.

Room and Elevated Temperature Tensile Tests

At room temperature, the ultimate tensile strengths and 0.2 per cent proof stresses of the cast and wrought alloys are almost equivalent. The elongation and reduction of area of the cast alloys are lower in all instances. The elongation and reduction of area values reported for the wrought steels were obtained on longitudinal samples from the forged and rolled plates. Transverse ductilities of wrought products would be expected to be lower.

At elevated temperatures 1000 and 1100 F (540 and 590 C) again, the ultimate tensile strengths and 0.2 per cent proof stresses do not differ appreciably. In steels *F* and *J* the elongation and reduction of area of the cast alloys have improved to such a degree that these properties approximate those of their wrought equivalents. In steel *H*, however, this large improvement in the tensile ductility has not occurred. Although this steel possesses the highest tensile strengths at 1000 F (540 C) and 1100 F (590 C), it should be noted that steels *F* and *J* have been tempered at temperatures 75-100 F (42-55 C) higher than *H*.

Fatigue Properties

Evans, Ebert and Briggs[1] have compared the fatigue properties of plain carbon and low alloy steels with tensile strengths of up to 170,000 psi. They found that the endurance ratio (fatigue strength divided by the ultimate tensile strength) for unnotched wrought steels was greater than the endurance ratio for cast steel. However, the endurance ratio for notched samples was about the same for both cast and wrought steels, having a value of about 0.27 to 0.32. The results of the present work are substantially in agreement with the results of these authors.

TABLE 3 — CHARPY V NOTCH IMPACT PROPERTIES OF HEATS A, F, H AND J

Heat	Charpy V Notch Impact – ft-lb: Room Temperature, Cast	Room Temperature, Wrought	−40 F, Cast	−40 F, Wrought
A	9.5	22.5	9.5	14.5
F	11.0	7.0	4.5	4.0
H	4.0	9.5	3.0	5.0
J	5.5	9.0	3.5	4.0

For the notched fatigue tests, however, the cast steel exhibits some superiority over the wrought. The ratio of the unnotched endurance limit to the notched endurance limit indicates a greater notch sensitivity in fatigue of the wrought steels. In comparing the secondary hardening steels, *F, H* and *J*, it is apparent that all steels, even though they differ in tensile properties, exhibit approximately the same endurance limits in the cast and wrought conditions for both notched and unnotched specimens.

The difference in the strength reduction factors of the cast and wrought steels does not appear to be a function of the grain size of the steels, since there is little apparent difference in grain size. This effect may be due to the directionality inherent in wrought steels.

Secondary Hardening Mechanism

Recent work[2,3] has shown that secondary hardening may be attributed to the formation of a coherent type alloy carbide precipitate at the temperature corresponding to the peak hardness in the hardness-tempering-temperature curve. This type of precipitate creates a high degree of lattice strain and inhibits slip processes in the steel. It has also been shown[4] that vanadium carbides are present in steels containing about 0.3 per cent vanadium on tempering at 1275 F (690 C).

TABLE 4 — FATIGUE PROPERTIES OF HEATS A, F, H AND J

Heat	Endurance Limit (E.L.) psi at 10^7 cycles				Endurance Ratio $= \frac{E.L.}{U.T.S.}$				Strength Reduction Factor $= \frac{\text{Unnotched E.L.}}{\text{Notched E.L.}}$	
	Unnotched		Notched		Unnotched		Notched			
	Cast	Wrought	Cast	Wrought	Cast	Wrought	Cast	Wrought	Cast	Wrought
A	77,000	81,000	30,000	26,000	0.362	0.376	0.141	0.121	2.56	3.12
F	64,000	105,000	55,000	49,000	0.355	0.568	0.300	0.265	1.16	2.14
H	68,000	113,000	60,000	50,000	0.288	0.459	0.254	0.203	1.13	2.26
J	62,000	107,000	43,000	51,000	0.300	0.517	0.208	0.246	1.44	2.11

TABLE 5 — CRITICAL POINTS FOR HEATS A, F, H AND J

Heat	Heating rate, C(F)/hr	Ac_1,C(F)	Ac_3,C(F)	Cooling rate, C(F)/hr	Ar_3,C(F)	Ar_1,C(F)
A	150(302)	720(1328)	787(1449)	150(302)	675(1247)	595(1103)
	150(302)	722(1332)	787(1449)	40(104)	680(1256)	605(1121)
F	150(302)	775(1427)	813(1494)	150(302)	723(1333)	680(1256)
	150(302)	775(1427)	813(1494)	40(104)	736(1357)	700(1292)
H	150(302)	833(1531)	875(1607)	150(302)	748(1347)	700(1292)
	150(302)	833(1531)	875(1607)	40(104)	780(1436)	760(1400)
J	150(302)	750(1382)	800(1472)	150(302)	382(720)	315(599)
	150(302)	750(1382)	800(1472)	40(104)	402(756)	313(595)

TABLE 6

Heat	Shepherd Fracture Grain Size	
	Cast	Wrought
A	6	5-6
F	4	4
H	5	5
J	3-4	3

Samples of steel were tempered above and below the secondary hardening peak temperature, and carbon replicas of the surface were examined with an electron microscope. The electron photomicrographs are shown in Figs. 4 to 9, inclusive.

It is clearly evident that at 1000 F (540 C) no separate alloy carbide is visible, and at this stage the Fe_3C has started to redissolve. Tempering at this temperature has resulted in the complete transformation of martensite to ferrite and cementite. After tempering at 1100 F (590 C) the iron carbides have been replaced by complex chromium-molybdenum carbides and vanadium carbide. At 1200 F (650 C) the carbides are more distinct and have increased in size, while at 1300 F (705 C) the carbides are easily

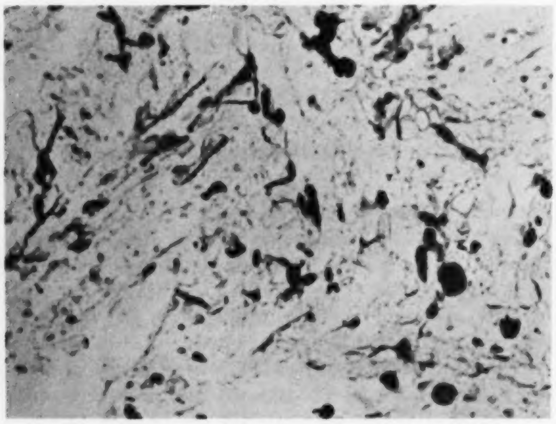


Fig. 4 — Electron photomicrograph of steel *F* sample after tempering 5 hr at 1000 F (540 C). The gray spots are cementite particles. 15,000 ×.

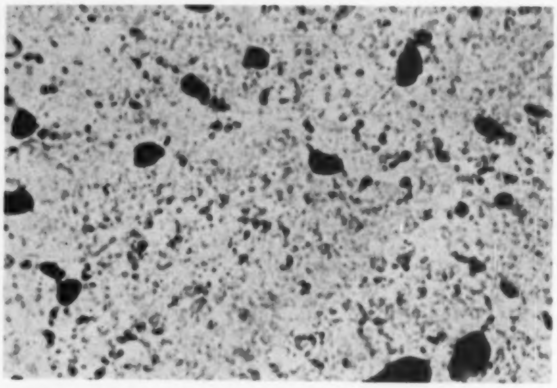


Fig. 5 — Electron photomicrograph of steel *F* sample after tempering 5 hr at 1100 F (590 C). Cloud-like vanadium carbides can be seen. 25,000 ×.

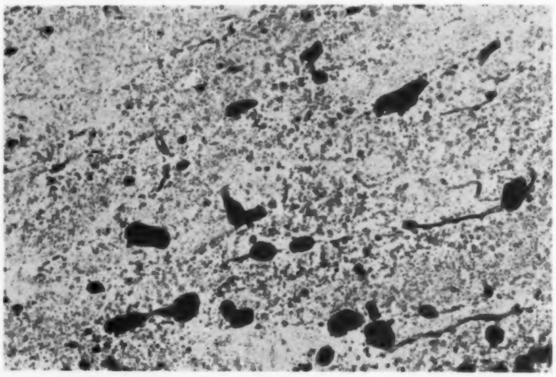


Fig. 6 — Electron photomicrograph of steel *F* sample after tempering for 5 hr at 1200 F (650 C). Fine vanadium carbides can be seen. 15,000 ×.

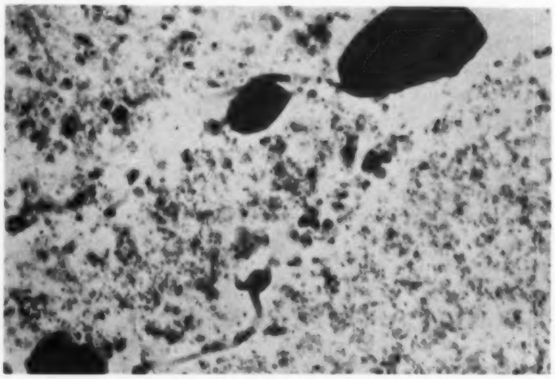


Fig. 7 — Electron photomicrograph of same sample as in Fig. 6. Tempering results at 1200 F (650 C) are shown in the formation of distinct vanadium carbides (small gray plates and thin dark lines). 50,000 ×.

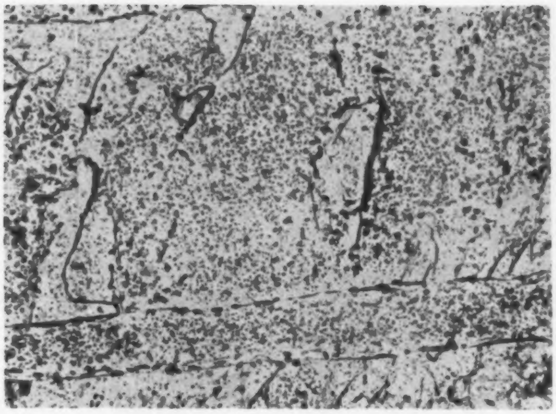


Fig. 8 — Electron photomicrograph of steel *F* sample after tempering at 1300 F (705 C) for 5 hr. Carbides within ferrite grains and concentrated at the grain boundaries can be seen. 15,000 ×.

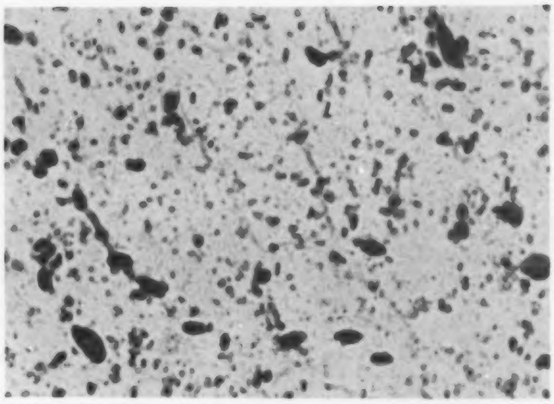


Fig. 9 — Electron photomicrograph of same sample as in Fig. 8. Thickness of the lines and darkness of the plates shows growth of carbides at tempering temperature of 1300 F (705 C). 50,000×.

resolved. These carbides tend to be concentrated at the grain boundaries (originally martensite needles) and also within the ferrite grains.

In order to obtain a quantitative picture of the carbides present in the steels after various austenitizing and tempering temperatures, samples of the steels were subjected to electrolytic carbide separation treatment. The results of the austenitizing and tempering temperatures effect on the weight of undissolved carbides are shown in Figs. 10 and 11. The need for the high austenitizing temperature is clearly shown in Fig. 10, in order to dissolve all of the stable alloy carbides.

Figure 11 shows that a minimum quantity of carbide remains after tempering at 1000 F (540 C), which corresponds approximately with the peak hardness in the hardness tempering temperature curves. The maximum amount of residue obtained at 850-900 F (455-480 C) corresponds to the minimum hardness in the hardness-tempering-temperature curves. Analysis of this residue shows it to be mainly Fe_3C. As the tempering temperature increases, the amount of undissolved carbide also increases, as is shown in Fig. 11, i.e., the coherent precipitate is forming a separate phase in the form of a noncoherent-type alloy carbide.

The maintenance of a high hardness and hot strength in the steels *F*, *H* and *J* may, therefore, be attributed to the presence of finely dispersed alloy carbides. As these carbides coalesce, the hardness decreases rapidly.

The microstructures of the cast and wrought steels used in this investigation are shown in Figs. 12 to 15, inclusive, at a magnification of 750 ×. The carbides are not resolvable at optical microscope magnifications, and require electron microscopy for resolution.

Further work is planned, to investigate modifications of standard deoxidation practices in an attempt to improve the room temperature cast ductility properties. Tests will also be carried out on the effect of vacuum ladle-degassing of the steels prior to casting.

CONCLUSIONS

The results reported indicate that these secondary hardening-type steels exhibit many desirable cast properties that could be utilized for service at elevated temperatures.

Although room temperature cast ductility is somewhat inferior to that of the wrought condition, this

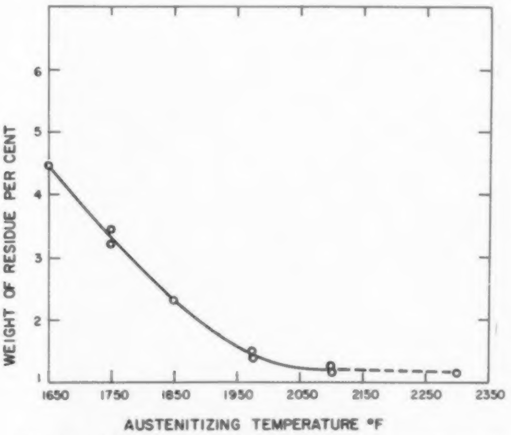


Fig. 10 — Graph showing austenitizing temperature vs. weight of residue (undissolved carbides) for steel *F*. Maximum resolution of carbides is obtained by increasing the austenitizing temperature to about 1950 F (1065 C).

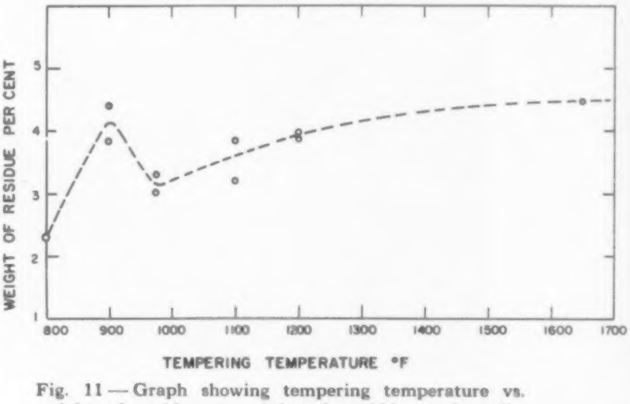
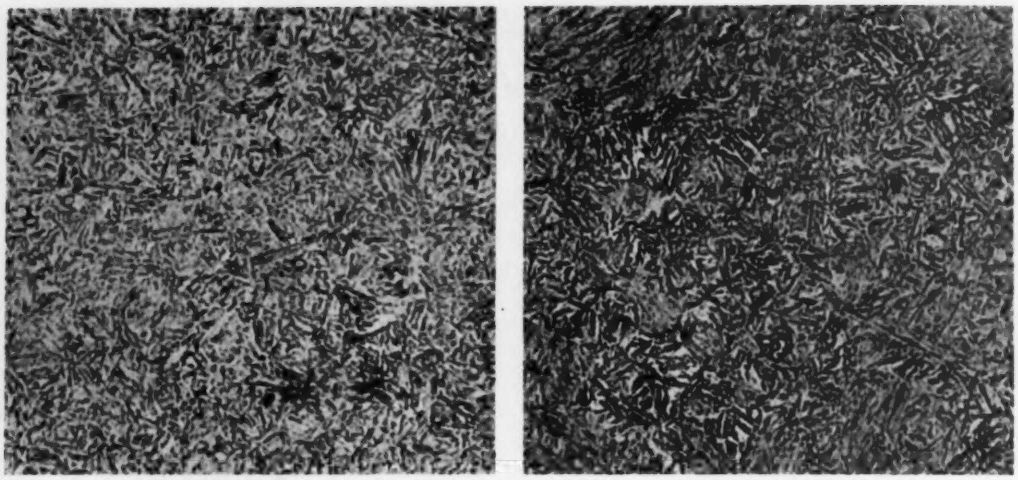
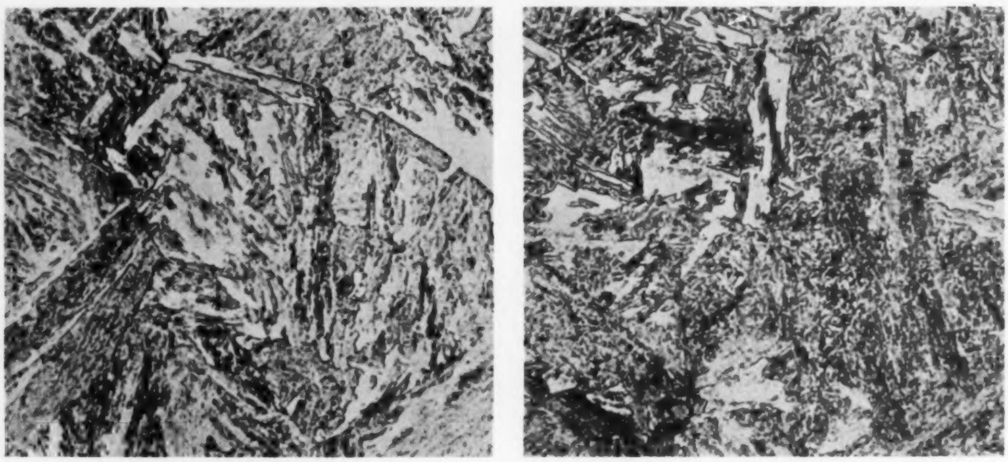


Fig. 11 — Graph showing tempering temperature vs. weight of residue (precipitated carbides and undissolved carbides). The point on the ordinate is the weight of residue in the as-quenched condition.



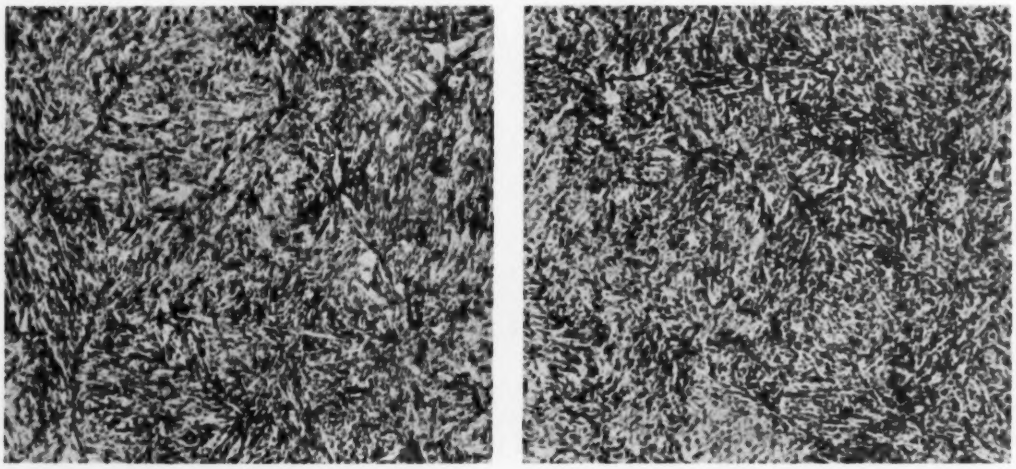
Wrought — Rc 41.0. Cast — Rc 43.5.

Fig. 12 — Microstructures of cast and wrought steels from heat *A*. 2 per cent nital etch. 750 ×.



Wrought — Rc 41.0. Cast — Rc 42.0.

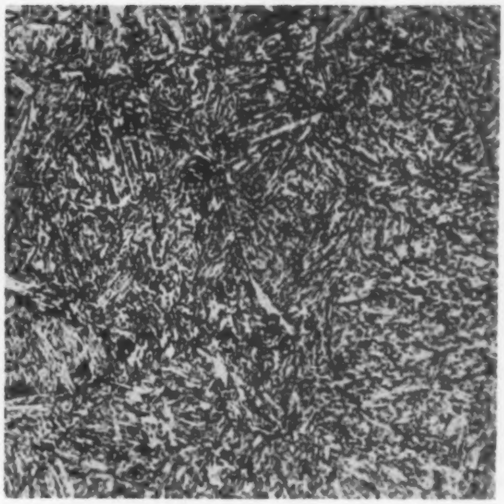
Fig. 13 — Microstructures of cast and wrought steels from heat *F*. 2 per cent nital etch. 750 ×.



Wrought — Rc 49.5. Cast — Rc 48.0.

Fig. 14 — Microstructures of cast and wrought steels from heat *H*. 2 per cent nital etch. 750 ×.

Wrought — Rc 42.5.



Cast — Rc 43.0.

Fig. 15 — Microstructures of cast and wrought steels from heat *J*. 2 per cent nital etch. 750 ×.

property becomes quite comparable at the higher temperatures for which these steels are designed.

Unnotched fatigue properties are much better for the wrought steel, but it has been shown that the wrought steels are much more notch sensitive than the cast steels. The fact that castings have no directionality properties is another favorable feature.

It has been confirmed that the secondary hardening in these steels is due to the precipitation of fine alloy carbides.

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STICKINESS IN CORE SAND MIXTURES

Final Report
AFS Sand Division
Committee 8-K

ABSTRACT

The major problems encountered in stickiness are dealt with. A outline of a method for determining the cause and possible corrective action necessary is given. Although the Retained Sand Test is not a standard AFS test, its reliability in certain uses is noted. Precautions necessary with this test are given.

INTRODUCTION

Stickiness in core sand mixtures has long been recognized as a problem by the foundry industry, but relatively little information was available on this subject. In an effort to alleviate this situation, a Core Stickiness Committee[1] was organized in 1953 under the direction of the American Foundrymen's Society. The purpose of this committee was to define stickiness, investigate methods for its evaluation and, if possible, recommend a suitable laboratory test procedure to measure the comparative severity of stickiness.

The first progress report by Wayne H. Buell was published in the AFS TRANSACTIONS in 1954. Progress reports two and three[2] by Donald S. Mills were published in 1956.

The current committee[3] has reviewed all of the work accomplished to date, and this report is submitted as a summation and finalization of this project. It has been concluded that the only known method of determining stickiness related to core sand mixtures is the "Retained Sand Method." This test is conducted by visual inspection or actual measurement of the quantity of sand which adheres to the core box surface after a pre-determined number of cores have been produced. The actual test procedure is outlined in detail in the aforementioned progress reports.

The results of the Committee work indicate that trials conducted in the laboratory can be correlated with the results obtained similarly in production. Even though correlations were obtained, the overall results indicate that this test has limited practical value and is, therefore, not recommended as a standard AFS test. The major reasons for this conclusion are:

1) The test is subject to error mainly because of the small quantities of materials involved which multiplies any errors in the testing procedure.
2) The laboratory tests must be performed in a similar manner to the methods employed in production or the results may be unreliable. These methods would include using the same core box material, blowing the test cores, if blowing is used in production, etc.
3) There may be less time and expense involved if stickiness is determined in production and the proper approach is used to correct the condition.

If this test is to be used for the purpose of evaluation, the following precautions must be observed whether the test is performed in the laboratory or in production:

1) The test is relative and is only useful in comparing one mixture to another.
2) The mixes to be compared must be prepared in precisely the same manner in order to compare results.
3) The preparation and treatment of the core box surfaces must be standardized and carefully observed throughout the test.
4) The mechanism for producing the cores must be standardized and observed such as air pressure, drawing facilities, etc.
5) The test must be repeated a sufficient number of times to eliminate reasonable doubt of error.

NO STANDARD TEST

It was quite apparent to the committee after reviewing the qualifications for conducting this test, that it would not be acceptable as a standard. Although several other types of tests were evaluated during the course of the investigation, these, too, possessed unsatisfactory qualifications and were not acceptable. It must be noted, however, that the "Retained Sand Test," when performed in strict adherence to the procedure, is reliable, and can be used where necessary to compare the relative stickiness of materials or mixtures. It is not felt that a standard test can be subjected to the precise qualifications and procedures required and still be generally used in industry and relied upon for control work.

Although the results of the committee work did not evolve a Standard Testing Procedure, a great deal of knowledge was gained on this subject through the laboratory and production tests which were performed. In order to preserve this knowledge, it was agreed to present this paper as the culmination of the work performed. The following outline on stickiness

is presented as an aid in overcoming this problem in production. This outline is an effort to summarize all of the findings, and present them in a form which can be used by operating personnel when stickiness is encountered.

Each major core process is covered, and the items listed are known to effect stickiness in varying degrees and should be evaluated when investigating a stickiness problem. The majority of the factors listed have been investigated and proved by the results of the committee work to effect stickiness, and the possible remedies are presented as a step to overcome the specific problem. The first series of items listed must be considered in any type of core making process used, and the items listed under the three types of processes apply specifically to these processes. This outline is not presented as a "cure-all" for the problem but only as a guide in conducting a thorough evaluation.

FACTORS AND TREATMENT RELATED TO STICKINESS

A. Factors Affecting All Core Making Processes Currently In Use.

1) *Sand.* Stickiness is considered to be a surface phenomenon in any type of process. The ultimate mulling practice is to surround each grain of sand with the particular binder in use. The total surface area per unit weight of sand is, therefore, the area of each sand grain to be covered multiplied by the total number of sand grains in a particular measure.

   In considering sand as a possible cause of stickiness, it must be remembered that the surface area per unit weight of sand is dependent on the grain size, shape and distribution of the sand in use. It is, therefore, logical to assume that any changes in the type of sand used may be responsible for stickiness. Most cases of stickiness due to sand may be eliminated by reviewing the size, shape and distribution so that it is consistent and by adjusting the moisture content, if used, and the binders to fit the surface area of the sand.
2) *Mulling.* Both the mulling time and procedure must be considered relative to stickiness. During the course of establishing the proper mulling cycle, not only the optimum strength values should be considered, but also the stickiness and flowability characteristics of the mixture should receive equal attention. Both the sequence of the additions to the mix and the mulling time for each material must be considered as they will effect stickiness.
3) *Additives.* All sand additives will change the total surface area of the mix. In order to compensate for this change, the moisture content, if used, and the binder content must be adjusted to develop the full properties of the mix. The additives, themselves, must also be investigated as some types of materials in use to overcome specific core problems are in themselves inherently sticky.
4) *Core box composition.* Stickiness may be related to the type of materials used in the construction of the core box. Some materials react quite differently to different types of mixtures. Stickiness should certainly be a consideration when the choice of core box material is to be made.
5) *Equipment.* Stickiness is also related to the mechanics of the core making process. One specific example is that the sand must feed properly through the blow machine hopper and into the core box. Unless a consistent flow of sand is maintained, compressed air will be blown directly onto the core box surface. It appears that this action destroys the surface film on the box and localized sticking will occur.
6) *Variations in sand temperature.* Any changes in sand temperature could be the cause of stickiness. In most processes, cool sand is most desirable for physical properties, handling, storage and particularly stickiness. Other processes utilize hot sand to develop optimum properties. In either case, it is not the actual sand temperature that is important since the process can be adopted to the condition. Variations, however, must be avoided since the process cannot be continually changed to compensate for this variable.

B. Oil-Cereal Binders.

Problems found with this process, but because of the type of binders used, do not affect the other processes.

1) *Water – Cereal Ratio.* If sufficient water is employed to develop the optimum green and dry properties with this process, the core sand mix may be expected to have poor flowability and be relatively sticky. Because of this fact, in normal core blowing practice, the moisture content is usually and necessarily reduced to promote flowability and prevent stickiness. The cereal-water ratio in some production mixes is, therefore, such that the mixture is lacking water with respect to some green properties, but particularly to the dry strengths.

   These values may be improved, within limits by increased and proper mulling time and procedure. The general rule is to use as much water as can be permitted without causing excessive stickiness and poor flowability.

   The problem of excessive sand temperatures would also be most apparent in this section since the moisture loss due to heat will change the water-cereal ratio and promote stickiness.
2) *Cleaning and conditioning core boxes.* The objective of conditioning a core box is to build up a thin film which will provide lubricity. The conditioning should not create an excessively wet condition because this may lead to other forms of stickiness. The core box cleaning operation should be designed to remove the dirt or other foreign materials but leave the lubricating film. This process is generally in the form of a solvent material used to clean the core box or a mild abrasive.
3) *Release Agents.* The normal purpose of release agents is to provide increased flowability in the storage hoppers and the blowing machines. It is also used directly on the core box to provide

lubricity, but it must be remembered that excessive amounts used either in the mix or on the core box can be detrimental. The sequence of addition of the release agent in the mulling cycle is also important.

The normal practice is to add the release near the end of the mixing cycle for the best overall results. The actual time is not as important as is the consistency of the cycle throughout the day's production.

4) *Handling and Storage of the Mix.* With some types of binders, the oxidation and loss of solvent may influence the stickiness of the mix. The relative tendency of the mix to air dry should be considered in relation to the storage and handling systems. Location of the storage hoppers relative to heat from core ovens, shape of the hoppers influencing flowability and quantity of sand mixed ahead of production are some of the factors which must be investigated.

C. Water-Soluble Binders.

The type of binders included are the silicates, some phenolic, urea and aldehyde base resin binders, sugar based materials and certain water soluble by-products that are being used as binders. The entire class of materials is notably lacking in lubricity and, therefore, stickiness is a primary problem.

These binders require a high moisture content to develop adequate dry properties. Due to the higher moisture requirement, the mixes tend to be sticky and lack flowability. In most all cases, a finer sand with a wide grain distribution will help to relieve or control the flowability and sticking problem. The general approach is to use a release agent in the sand to achieve the necessary lubricity. It has been found with the resin type materials, particularly, that a release agent of some type is essential, but the quantity must be controlled because this type of material will effect the other properties of the mix.

D. Shell Cores and Molds.

The process also requires a release agent usually in the mixture and on the core box surface. The temperatures used must be considered in the selection of the release since the ability to withstand heat is a primary concern. Normally waxes or some types of metallic stearates are used in the sand mix, and some waxes and silicones are used on the core box surface. It is also well to note that release agents used in the core sand mix has other functions which must be considered.

In some cases the prevention of caking in the hoppers or machines is a function of the release as well as reducing shear strength while the sand is being mixed. There is no set pattern at present on the order of addition or the time cycle in adding these materials to the mix, but these factors will influence the effectiveness of the release in the mix.

SUMMARY

This report has dealt with the major problems encountered in stickiness, and has outlined a method of determining the cause and possible corrective action necessary. The "Retained Sand Test" has not been submitted as an AFS standard because of the limitations and precise qualifications for performing the test. It has been noted, however, that this test can be used to correlate production results where necessary.

There is no simple solution to stickiness because of the numerous variables involved, but this property can be controlled through proper application of the known variables which affect this condition. Any further work on this subject will be referred to the appropriate AFS Technical Committee if a new approach to a test procedure is forthcoming.

ACKNOWLEDGEMENT

During the course of the committee work, there has been considerable time and effort expended on this subject. Acknowledgement is made to the following: Harry W. Dietert Co., A. L. Graham, R. Glass and T. Daksiewicz; Aristo Corp., W. H. Buell and M. Dombrowski; Lanhoff Grain Co., J. E. Huss; National Engineering Co., T. V. Linabury; General Motors Corp., D. S. Mills, H. J. Hughes, Jr., A. L. Bryant, S. McComb.

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MAGNESIUM CASTING ALLOY EK31XA

By K. E. Nelson

ABSTRACT

Magnesium casting alloy EK31XA (Mg + 3.2 per cent didymium + 0.6 per cent zirconium) is rated with the commercial magnesium-rare earth metal-zirconium alloys as second in castability to the magnesium-aluminum-zinc alloys. This alloy combines good room temperature tensile properties with excellent tensile strength at elevated temperatures up to about 600 F. These properties, in addition to excellent creep resistance at elevated temperatures for times up to 10 hr, should prove attractive to rocket and missile designers.

Its long term properties (creep strength up to 1000 hr) should be of interest in applications operating up to about 450 F. EK31XA alloy can be welded by argon-arc or heli-arc methods, and requires no special procedures in applying surface protecting treatments.

INTRODUCTION

The magnesium-rare earth metal system of alloys has received considerable attention from investigators interested in both wrought and casting alloys. In the United States, Leontis pioneered these investigations on the binary alloys,[1,2] writing two papers which point out the effects of varying additions of the individual rare earth elements on their tensile and creep properties. Ternary and quaternary alloys of this system have also been evaluated. Pashak and Leontis[3] are reporting on wrought alloys while Leontis and Feisel[4] presented properties of casting alloys.

This latter paper shows the advantages of magnesium-didymium*-zirconium alloys over other combinations of rare earth metals in magnesium-zirconium alloys. A patent issued[5] covers magnesium alloys containing essentially at least 85 per cent magnesium, at least 0.4 per cent zirconium and from 0.5 to 4.0 per cent rare earth metal, of which neodymium constitutes at least 50 per cent of the rare earth metal, lanthanum plus cerium do not exceed 25 per cent together and the balance consisting of other rare earth metals.

A more recent publication by Payne and Bailey[6] presents information on alloys containing magnesium-rare earth metal-silver-zirconium, in which the rare earth metal was added as didymium. One composition has been given the English designation "MSR" or, using the A.S.T.M. system of nomenclature, QE22 alloy. This magnesium alloy, containing silver, didymium and zirconium, is claimed by the English to possess a yield strength comparable to some of the better aluminum alloys, with an ultimate strength sufficiently high in relation to yield strength to permit full advantage of these high yield values in design.

Limited information available on QE22 alloy indicates that while the yield and ultimate strength of EK31XA-T6 is lower than QE22 at room temperature, they become superior to QE22 properties as testing temperature increases.

As shown by Leontis and Feisel,[4] the optimum combination of strength and ductility in magnesium-didymium-zirconium alloys is obtained at about 3 per cent didymium. Accordingly, it was decided to evaluate further a composition containing nominally magnesium—3.2 per cent didymium and 0.6 per cent zirconium. This paper discusses castability, heat treatability, tensile and creep properties and physical properties of the alloy which is designated EK31XA-T6, according to the A.S.T.M. system of nomenclature.

The chemical composition of EK31XA, the recommended heat treatment and some of the physical properties of this alloy are listed in Tables 1 and 2. The term castability, as used in this paper, refers to the ability of an alloy to fill a sand mold satisfactorily and to form a casting relatively free of deleterious defects.[7]

A discussion of the techniques of alloy preparation and casting production, as well as testing methods, is appended to the paper.

DISCUSSION OF RESULTS

Castability

The measure of the degree of castability of EK31XA alloy is limited to the observations made during the pouring of the castings in the laboratory and production foundries, and to the quality of these castings as shown by various inspection techniques. The pouring times required to fill the molds were not significantly different for EK31XA alloy as compared to the commercial magnesium-rare earth metal-zirconium alloys.

Castability studies made on several magnesium-rare earth metal-zirconium alloys[7] indicated that "cope pitting" was a characteristic of these alloys.

*Rare earth metal consisting essentially of 85% neodymium and 15% praseodymium.

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Control of turbulence of the metal stream before it enters the mold cavity has been found necessary to minimize the cope pitting condition and to minimize the formation of oxide skins. Because the severity of the pitting in EK31XA alloy is comparable to that found in the commercial magnesium-rare earth metal-zirconium alloys, the gating used to control turbulence with the commercial magnesium-rare earth metal-zirconium alloys should prove satisfactory with EK31XA alloy.

Two types of segregation have been observed in castings of the magnesium-rare earth metal-zirconium and magnesium-thorium-zirconium alloys,[21,22,23] namely:

1) Gravity-type segregation presumed to be metallic zirconium, and usually present as small dense inclusions observed by radiography.
2) Eutectic-type segregation usually observed as a dense lined-up formation in a radiograph.

Both types of segregation have been observed in alloy EK31XA, and while some casting designs are susceptible to such segregation proper handling of the molten metal and correct gating and risering will go a long way toward its elimination and result in good quality castings.

The magnesium-rare earth metal-zirconium alloys have a relatively low microshrinkage tendency. For some reason as yet not explained, EK31XA is inferior to the ternary magnesium-rare earth metal-zirconium alloys EK30A and EK41A in its tendency toward microporosity. It might be classified as comparable to such alloys as AZ92A and AZ91C in this respect. "Swirl" type microporosity noted in ZK51A alloy[24]

TABLE 1 — CHEMICAL COMPOSITION AND HEAT TREATMENT OF EK31XA ALLOY

Element	Composition Range, %	Heat Treatment
Didymium*	2.5-4.0	975±5 F for 12 hr in an atmosphere of 1.0-1.5% SO_2.
Zirconium	0.40-1.0	
Total Other Impurities (Maximum)	0.30	Rapidly cool to room temperature. 400 F for 16 hr.
Magnesium	Balance	

*Essentially 85% neodymium and 15% praseodymium.

TABLE 2 — PHYSICAL PROPERTIES OF ALLOY EK31XA-T6

Specific Gravity (68 F)	1.79
Density, lb/cu in.	0.065
Approximate Melting Range	
Liquidus	1197 ±5 F
Solidus	1040 ±5 F
Electrical Resistivity in Microhm, cm	
At 68 F	7.2
At 400 F	10.7
At 500 F	12.2
Thermal Conductivity in cal./cm²/cm/°C/sec.	
At 68 F	0.23
At 400 F	0.26
At 500 F	0.26
Coefficient of Thermal Expansion (68-212 F), /°F	0.0000145
Corrosion Rate in milligrams/cm²/day (range)	0.24-0.29*

*Limited data determined in 3% NaCl solution using a 14-day alternate immersion test.[20]

has been seen in alloy EK31XA. It can be expected that design limitations will be encountered with simpler castings in EK31XA alloy than with EZ33A alloy when freedom from microshrinkage is a requisite.

Draws are defined as surface shrinkage defects usually found at the junction between a massive section and a web. This condition results in a surface depression or separation in the casting wall while it is in the semi-solid state. EK31XA is comparable to the commercial magnesium-rare earth metal-zirconium alloys in draw tendency.

"Surface sinks" occur in a massive part of a casting solidifying under poor conditions of feeding.[24] The rather narrow solidification range of EK31XA results in an incidence of surface sinks comparable to HK31A alloy, higher than would be found in magnesium-aluminum-zinc alloys and somewhat worse than found using EZ33A alloy.

Shrinkage factors for EK31XA alloy are comparable to the values used for EZ33A alloy. As a rule of thumb, a shrink factor of $\frac{5}{32}$-in./ft can be used for green sand and $\frac{9}{64}$-in./ft on sand cores. As is true with all alloys, the casting design and location of gates and risers will also affect the actual shrinkage.

Heat Treatment

EK31XA is a precipitation hardening alloy, and requires a solution heat treatment followed by an artificial aging treatment in order to develop maximum properties. This alloy is quite sensitive to quenching rate subsequent to solution heat treatment, and requires a relatively rapid quench in order to develop optimum properties.

Various quenching media were used in obtaining cooling rates from the solution heat treat temperature of separately-cast test bars and slope castings. Figure 1 shows cooling rates obtained on separately-cast test bars, while Figs. 2 and 3 record the rates in thin and thick sections of slope castings. Tensile properties obtained with the various quenching conditions are given in Tables 3 and 4.

In order to eliminate bars containing microporosity, and to present a truer picture of the effect of section size and cooling rates on tensile properties, the *C* location[11] in the slope casting was used for thick sections, while *I* and *J* locations[11] were used for thin sections. Generally, the bar from the *C* location was free of microporosity. Some variations in elongation and tensile strength are caused by oxide inclusions in the bar.

It can be seen, by comparing the tensile properties in Tables 3 and 4, that the thinner wall cast test bars can be given an adequate quench more readily than the thicker sectioned parts such as the slope castings. A cooling rate from the solution heat treat temperature to 400 F of 1 F/sec is adequate for acceptable properties.

Creep Limits

Creep limits of 100 hr were obtained on bars sectioned from thick sections of slope castings which had been quenched at different rates. Results in Table 5 show the sensitivity of creep strength to cooling rate.

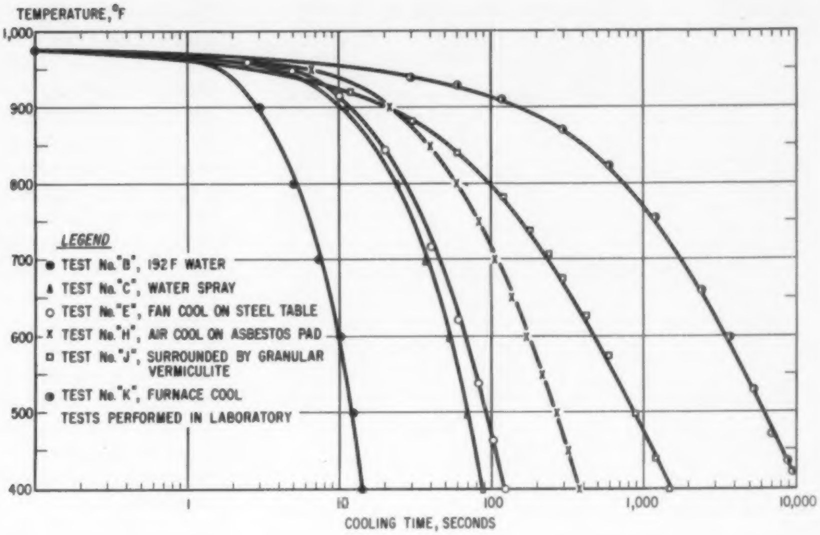

Fig. 1 — Quenching media effect on the cooling rate of EK31XA separately cast test bars.

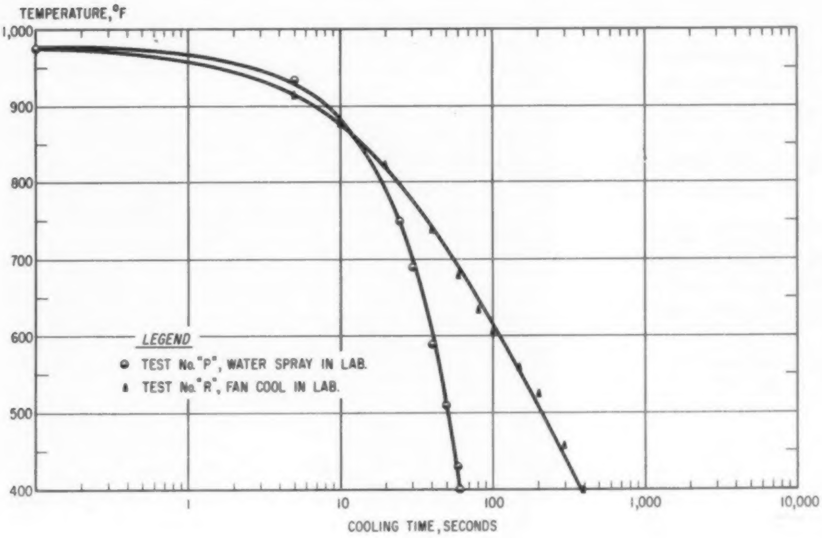

Fig. 2 — Quenching media effect on the cooling rate of EK31XA slope castings, thin section.

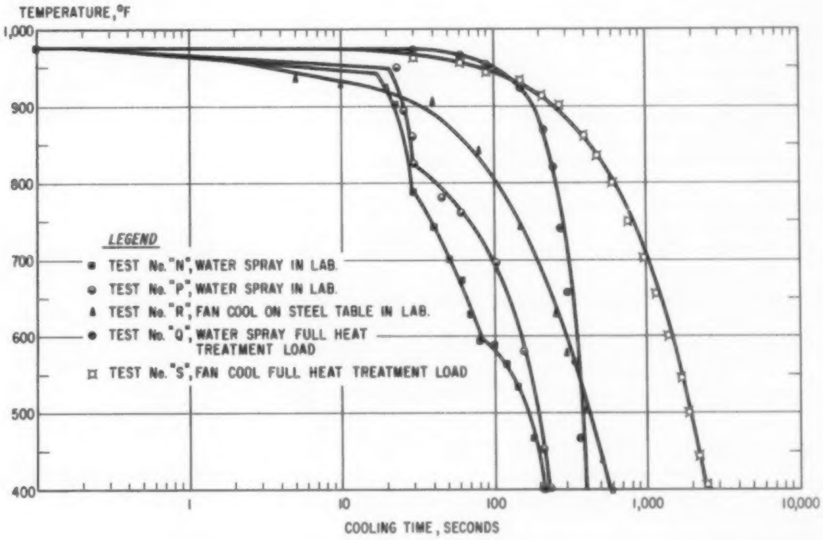

Fig. 3 — Quenching media effect on the cooling rate of EK31XA castings, thick sections.

TABLE 3 — EFFECT OF COOLING RATE FROM THE SOLUTION HEAT TREAT TEMPERATURE ON THE TENSILE PROPERTIES OF EK31XA-T6 SEPARATELY-CAST TEST BARS

Test No.	Type of Quench	Cooling Rate*	Tensile Properties TS	YS	Elong., %
A[1]	Ice water	<6 sec	36.4	22.6	6.0
B[1]	192°F water	14 sec	33.2	21.8	4.0
C[1]	Water spray	1 min, 25 sec	35.5	23.7	3.5
D[2]	Water spray	2 min, 39 sec	33.6	20.3	4.5
E[1]	Fan cool on steel table	2 min	35.4	22.4	4.0
F[2]	400 F oil bath	4 min, 40 sec	34.1	21.1	5.0
G[1]	Air cool on steel table	5 min	37.0	23.4	5.5
H[1]	Air cool on asbestos pad	6 min, 15 sec	33.5	21.9	3.5
J[1]	Surrounded by granular vermiculite	25 min	31.2	20.2	5.0
K[1]	Furnace cool	3 hr	26.2	15.3	6.0

1. Analysis: TRE as Di = 3.49%, Sol. Zr = 0.57%.
2. Analysis: TRE as Di = 3.35%, Sol. Zr = 0.54%.
*Time to cool from 975 F to 400 F.
TS = Tensile strength, 1000 psi.
YS = Yield strength, 1000 psi.
Elong., % = Elongation in 2 in.
Quenching done in laboratory.

The three conventional creep limits presented may be defined as follows:

1) Limiting stress to give 0.1 per cent creep extension.
2) Limiting stress to give 0.2 per cent total extension.
3) Limiting stress to give 0.5 per cent total extension.

TABLE 4 — SECTION SIZE AND COOLING RATE FROM THE SOLUTION HEAT TREAT TEMPERATURE EFFECT ON THE TENSILE PROPERTIES OF BARS SECTIONED FROM EK31XA-T6 SLOPE CASTINGS

Test No.	Type of Quench	Cooling Rate*	Section Size, in.	Tensile Properties TS	YS	Elong., %
L[1]	74 F Water	<30 sec	3	36.7	20.0	8.0
	74 F Water	<30 sec	5/16	36.9	20.5	6.0
M[1]	170 F water	<30 sec	3	33.2	19.8	4.0
	170 F water	<30 sec	5/16	38.6	21.2	9.5
N[1]	Water spray	3 min, 15 sec	3	36.2	20.1	6.0
	Water spray	————	5/16	40.9	21.8	12.0
P[2]	Water spray	3 min, 27 sec	3	31.2	19.2	4.7
	Water spray	1 min, 2 sec	5/16	36.4	20.7	6.0
Q[3]	Water spray a full heat treat load	6 min, 15 sec	3	34.8	19.5	4.5
	Water spray a full heat treat load	————	1/4	34.7	20.5	3.0
R[2]	Fan cool on steel table	9 min, 35 sec	3	29.4	18.7	3.3
	Fan cool on steel table	6 min, 40 sec	5/16	33.4	20.5	4.0
S[3]	Fan cool a full heat treat load	40 min, 30 sec	3	26.5	14.5	4.0
	Fan cool a full heat treat load	————	1/4	29.0	16.6	4.0

1. Analysis: TRE as Di = 3.40%, Sol. Zr = 0.53%. Quenching done in laboratory.
2. Analysis: TRE as Di = 3.35%, Sol. Zr = 0.54%. Quenching done in laboratory.
3. Analysis: TRE as Di = 3.16%, Sol. Zr = 0.52%. Quenching done in production foundry.

*Time to cool from 975 F to 400 F.
TS = Tensile strength, 1000 psi.
YS = Yield strength, 1000 psi.
Elong., % = Elongation in 2 in.

These creep parameters were obtained by interpolation of log-stress versus log-extension plots of the original data. Total extension represents the total deformation which occurs during both the loading and the creep extension testing period, while creep extension is the extension at constant stress and temperature is a function of time after the specimen is loaded. The expansion of the sample due to temperature is not included in any of these measurements.

Figures 4 and 5 show the microstructure of EK31XA-T6 which has been quenched at different rates. Figure 5 shows that there is a rather coarse precipitate within each grain which is associated with a drastic lowering of the strength properties of the alloy. Another indication of inadequate quenching is the presence, at the grain boundaries, of rods of precipitate having appreciable width rather than thin, continuous grain boundaries. Similar structures can be seen when the alloy is exposed above 500 F for long times.

Mechanical Properties

Tensile properties of test bars machined from individual castings were obtained by testing at room temperature, 300, 400, 500 and 600 F. The average and

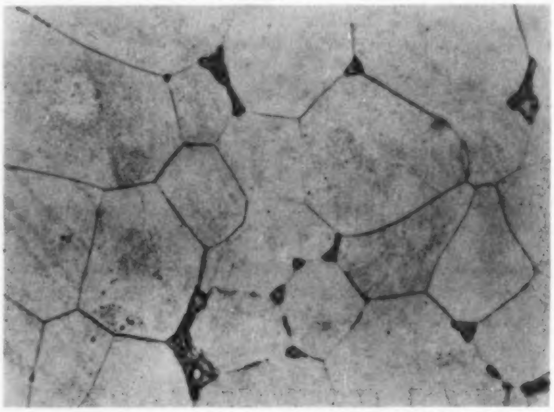

Fig. 4 — Structure of sand cast EK31XA-T6 alloy which has received a rapid quench from the solution heat treat temperature. Glycol etch. 250 ×.

TABLE 5 — EFFECT OF COOLING RATE FROM THE SOLUTION HEAT TREAT TEMPERATURE ON THE CREEP STRENGTH OF BARS SECTIONED FROM EK31XA-T6 SLOPE CASTINGS

Test No.	Type of Quench	Cooling Rate*	100-Hr Creep Limits, 1000 psi: 0.1% Creep Extension	0.2% Total Extension	0.5% Total Extension
T[1]	Water spray	3 min, 39 sec	9.7	8.0	13.0
U[1]	Water spray	4 min, 4 sec	10.7	9.0	13.3
Q[2]	Water spray a full heat treat load	6 min, 15 sec	10.5	8.7	13.9
S[2]	Fan cool a full heat treat load	40 min, 30 sec	7.5	7.0	9.2

*Time for 3-in. section to cool from 975 F to 400 F.
1. Analysis: TRE as Di = 3.16%, Sol. Zr = 0.52%. Quenching done in laboratory.
2. Analysis: TRE as Di = 3.16%, Sol. Zr = 0.52%. Quenching done in production foundry.

range of values at each testing temperature and the melt analysis from which the castings were poured are shown in Table 6. These castings had received an adequate quench from the solution heat treat temperature. Some of the lower properties were influenced by oxide skins and microporosity.

The average tensile properties and the standard deviation values,[7] as well as the number of values used for each determination, are listed in Table 7. The results of tension tests in Tables 7 and 8 show that bars sectioned from castings are roughly comparable in strength to separately-cast bars. A comparison of average tensile properties of separately-cast test bars of various magnesium alloys is made in Table 9.

Tension stress-strain measurements taken on EK31XA-T6 test bars at room and at elevated temperatures, obtained at a testing speed of 0.005 in./in./min, are shown in Fig. 6. There is little effect of strain rate on the strength of EK31XA-T6 alloy through 400 F, as shown in Figs. 7 and 8. Effects of strain rate are important in applications where loads are rapidly applied to the structure.

The effect of exposure for various lengths of time at elevated temperatures on the tensile strength of this alloy is shown in Figs. 9 and 10.

Creep tests on bars sectioned from EK31XA-T6 castings were made for times up to 1000 hr. Table 10 presents 100-hr and 1000-hr creep limits of EK31XA-T6 alloy, with a comparison of creep limits of other magnesium casting alloys being made in Table 11. Effects of exposure at elevated temperatures prior to standard creep testing at 400 F and 500 F are small, as shown in Fig. 11.

In order to provide the designer with some indication of allowable stress, and resulting deformation at a given temperature for short-time applications, isochronous stress-strain curves for EK31XA-T6 alloy are shown in Figs. 12-17. As explained in an earlier publication,[19] these figures are prepared from short-time creep data. The short-time creep strength of EK31XA-T6 is compared with other magnesium alloys in Figs. 18 and 19.

The effect of temperature on the modulus of elasticity of EK31XA-T6 alloy is reported in Table 12.

Laboratory-produced test castings were used to perform bearing and shear tests at 75, 400 and 600 F, as well as hardness measurements at room temperature. Results are shown in Table 13.

Welding and Straightening

Limited experience on the repair welding of EK31XA alloy castings indicates they are readily weldable by argon-arc and heli-arc methods using EZ33A welding rod. Castings should be welded in the T4 (solution heat treated) or in the T6 (solution heat treated plus aged) temper. In unrestrained sections, preheating is required. Thin-wall or restrained sections may require a short preheat at 400 F. Whether the casting is welded in the T4 or in the T6 temper, a post-weld treatment of 16 hr at 400 F is mandatory.

Straightening of EK31XA castings when required, should also be done in the T4 or the T6 temper. Correction of minor deflections can be done with

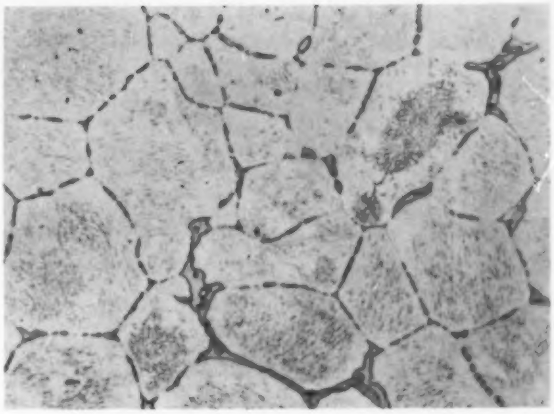

Fig. 5 — Structure of sand cast EK31XA-T6 alloy which has received an inadequate quench from the solution heat treat temperature. Glycol etch. 250 ×.

the casting at room temperature, while major straightening should be carried out at 400 F. All straightening operations should be followed with a regular aging treatment of 16 hr at 400 F. Stress relaxation tests have not been made with this alloy.

The sensitivity of the properties of this alloy to exposure at elevated temperatures requires that close controls be placed over exposure time and temperature, both during welding and during straightening operations.

Surface Protection

As shown by the corrosion rate reported in Table 2, resistance of EK31XA alloy to saline attack is equivalent to the better magnesium alloys. Applications considered in this composition should be carefully reviewed to determine the optimum protective system that can be applied. This alloy is similar to the commercial magnesium-rare earth metal-zirconium al-

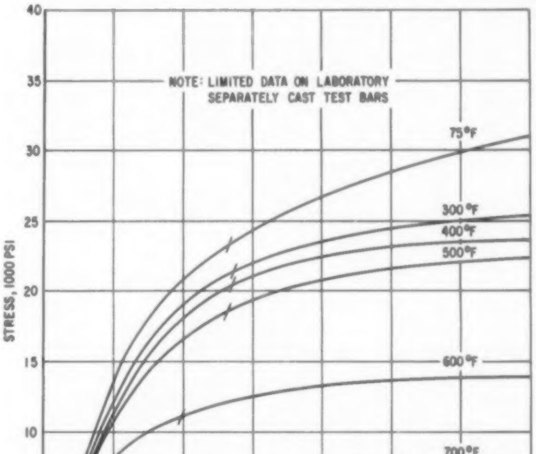

Fig. 6 — Tension stress-strain curves for cast EK31XA-T6.

TABLE 6 — EFFECT OF TESTING TEMPERATURE ON THE TENSILE PROPERTIES OF BARS SECTIONED FROM INDIVIDUAL CASTINGS — EK31XA-T6 ALLOY

				Testing Temperature, F																			
				75				300				400				500				600			
Casting Number	TRE as Di, %	Sol. Zr, %		No. of Bars	TS	YS	E, %	No. of Bars	TS	YS	E, %	No. of Bars	TS	YS	E, %	No. of Bars	TS	YS	E, %	No. of Bars	TS	YS	E, %
A	3.04	0.58	Ave.	25	30.5	20.0	4.0					16	24.7	17.7	11.8	16	19.2	15.1	22.8	16	13.2	9.6	57.1
			range		25.4	17.6	2.5						21.9	15.9	6.0		17.4	13.9	13.0		11.3	8.3	28.0
					−36.3	−21.7	−7.0						−27.0	−18.5	−22.0		−21.3	−16.6	−38.0		−14.9	−10.8	−80.0
B	3.23	0.56	Ave.	10	32.2	20.4	4.2					9	27.3	19.0	15.9	8	20.2	16.2	36.6	7	14.1	10.9	53.7
			range		29.4	17.6	2.5						26.1	18.3	7.0		19.1	14.7	23.0		13.0	9.9	22.0
					−36.6	−21.4	−6.0						−28.2	−19.8	−20.0		−21.1	−17.1	−43.0		−14.6	−11.7	−92.0
C	3.23	0.56	Ave.	22	33.0	21.0	4.2					6	25.2	17.8	11.8	6	19.5	15.0	25.3	6	14.0	10.2	55.5
			range		26.0	19.6	2.0						22.2	15.8	7.0		19.0	13.8	12.0		13.3	8.7	27.0
					−35.9	−22.9	−6.0						−27.4	−20.0	−17.0		−20.0	−16.2	−36.0		−15.5	−12.2	−68.0
D	3.23	0.56	Ave.	8	29.9	20.1	2.8					8	25.3	17.1	14.4	8	20.0	15.2	27.0	8	13.2	10.3	72.6
			range		27.7	19.4	2.0						24.5	16.3	10.0		18.6	14.2	23.3		12.5	9.4	58.0
					−32.4	−21.4	−4.0						−26.0	−17.7	−19.0		−21.1	−15.9	−33.0		−14.4	−12.4	−108.0
Slope Casting "L"	3.40	0.53	Ave.	9	35.7	20.2	6.0																
			range		32.7	17.9	4.7																
					−36.9	−20.9	−8.0																
Slope Casting "M"	3.40	0.53	Ave.	9	34.5	19.9	5.3																
			range		31.3	17.8	4.0																
					−38.6	−21.2	−9.5																
Slope Casting "N"	3.40	0.53	Ave.	9	36.1	20.5	7.1																
			range		30.4	18.4	3.3																
					−40.9	−21.8	−12.0																
Slope Casting "P"	3.35	0.54	Ave.	9	32.9	20.0	5.0																
			range		29.4	19.1	4.0																
					−36.4	−20.9	−6.5																
Slope Casting "Q"	3.16	0.52	Ave.	10	34.7	20.5	4.5	4	29.3	19.0	11.2	4	29.1	19.6	13.8	4	25.4	17.8	24.2	4	16.2	12.6	41.0
			range		28.9	19.5	1.5		28.6	18.3	10.0		28.2	18.6	8.0		24.3	17.2	20.0		14.9	12.2	26.0
					−39.0	−22.1	−7.5		−30.0	−19.6	−13.0		−30.6	−20.6	−18.0		−26.3	−18.3	−30.0		−18.5	−12.9	−55.0
Slope Casting "R"	3.35	0.54	Ave.	9	30.3	19.3	3.8																
			range		27.3	18.6	2.7																
					−33.4	−20.5	−4.7																

Slope casting designations refer to the type of quench described in Table 5.
TS = Tensile strength, 1000 psi.
YS = Yield strength, 1000 psi.
E, % = Elongation in 1 or 2 in.

The average values were obtained arithmetically.
Bars held 10 min at temperature before testing.

TABLE 7 — AVE. TENSILE PROPERTIES AND THE STANDARD DEVIATION OF BARS SECTIONED FROM EK31XA-T6 CASTINGS

Property*	Testing Temp., F	No. of Tests	Ave.	Standard Deviation
TS	75	127	32.6	3.2
YS	75	127	20.2	1.0
E, %	75	127	4.6	1.5
TS	300	4	29.3	—
YS	300	4	19.0	—
E, %	300	4	11.2	—
TS	400	47	26.1	1.9
YS	400	47	18.2	1.2
E, %	400	47	13.8	5.3
TS	500	42	20.2	—
YS	500	42	15.5	1.3
E, %	500	42	26.7	10.1
TS	600	41	13.8	1.1
YS	600	41	10.4	1.2
E, %	600	41	58.0	19.0

* TS = Tensile strength, 1000 psi.
YS = Yield strength, 1000 psi.
E, % = Elongation in 1 or 2 in.
Note: Where no standard deviation is listed, the average value for that property is the arithmetic average of the individual values.
Bars held 10 minutes at temperature before testing.

TABLE 9 — COMPARISON OF AVERAGE TENSILE PROPERTIES OF SEPARATELY-CAST TEST BARS OF VARIOUS MAGNESIUM ALLOYS

Composition	Testing Temp., F	Properties* TS	YS	E, %
AZ92A-T6	75	40	23	2
	200	37	21	25
	300	28	17	35
	400	17	12	36
	500	11	8	33
ZH62A-T5	75	40	27	8
	200	33	23	20
	300	26	20	24
	400	19	15	28
	500	14	10	30
EZ33A-T5	75	23	16	3
	200	23	15	5
	300	22	14	10
	400	21	12	20
	500	18	10	31
	600	12	8	50
HK31A-T6	75	31	16	6
	200	29	16	8
	300	27	15	12
	400	24	14	17
	500	23	13	19
	600	20	12	22
HZ32A-T5	75	29	15	6
	200	26	14	15
	300	22	12	23
	400	17	10	33
	500	14	9	39
	600	12	8	38
EK31XA-T6	75	35	22	4.5
	400	29	20	17
	500	21	17	28
	600	15	12	49

TS = Tensile strength, 1000 psi.
YS = Yield strength, 1000 psi.
E, % = Elongation in 2 in.
*Bars held 10 min at temperature before testing.

TABLE 8 — TENSILE PROPERTIES OF SEPARATELY-CAST TEST BARS POURED AND HEAT TREATED WITH CASTINGS EK31XA-T6 ALLOY

Testing Temp., F	No. of Bars	TS Range	TS Ave.	YS Range	YS Ave.	E, % Range	E, % Ave.
75	46	31.3-38.0	35.1	18.5-24.2	21.8	2.0-7.0	4.5
400	9	22.5-32.1	28.6	16.5-22.7	20.3	13.0-22.0	17.2
500	7	18.7-22.8	20.6	14.9-19.4	17.4	22.5-37.5	28.4
600	8	11.8-18.6	15.2	8.6-16.2	12.5	40.0-73.0	48.9

TS = Tensile strength, 1000 psi.
YS = Yield strength, 1000 psi.
E, % = Elongation in 2 in.
Bars held 10 min at temperature before testing.

TABLE 10 — CREEP RESISTANCE OF EK31XA-T6 BARS SECTIONED FROM CASTINGS*

Range of Creep Limit Values, 1000 psi., 100-hr

Testing Temp. F	No. of Test Bars	0.1% Creep Extension	0.2% Total Extension	0.5% Total Extension
400	24	8.1-11.7	6.4-9.4	10.0-13.1
500	14	1.9- 3.6	2.3-3.8	3.1- 4.4
600	10	0.6- 1.3	0.8-1.5	1.2- 1.8

Range of Creep Limit Values, 1000 psi., 1000-hr

Testing Temp. F	No. of Test Bars	0.1% Creep Extension	0.2% Total Extension	0.5% Total Extension
400	11	3.9-6.7	4.4-6.5	6.8-8.6
500	11	0.8-1.6	1.2-2.2	1.9-2.9
600	8	0.3-0.7	0.5-0.9	0.7-1.1

*Bars from laboratory test casting and from castings made in the production foundry.

TABLE 11 — COMPARISON OF RANGES OF 0.2% TOTAL EXTENSION CREEP LIMITS IN 100 HR OF BARS SECTIONED FROM VARIOUS MAGNESIUM ALLOY CASTINGS

Composition	Testing Temp., F	Number of Test Bars	Range Stresses Required to Produce 0.2% Total Extension in 100 hr, 1000 psi.
EZ33A-T5	400	41	5.8- 9.0
HK31A-T6	400	24	7.8-10.6
HZ32A-T5	400	31	6.5- 9.4
EK31XA-T6	400	24	6.4- 9.4
HK31A-T6	500	9	5.4- 7.0
HZ32A-T5	500	30	5.4- 7.5
EK31XA-T6	500	14	2.3- 3.8
EZ33A-T5	600	33	0.9- 1.6
HK31A-T6	600	25	2.1- 3.6
HZ32A-T5	600	42	2.8- 4.9
EK31XA-T6	600	10	0.8- 1.5

TABLE 12 — TEMPERATURE EFFECT ON THE MODULUS OF ELASTICITY OF EK31XA-T6 ALLOY

Temperature, F	Modulus* (psi x 10^6)
75	6.4
300	6.2
405	5.9
505	5.8
600	5.3
615	5.2
700	4.6

*Ave. of three tests.

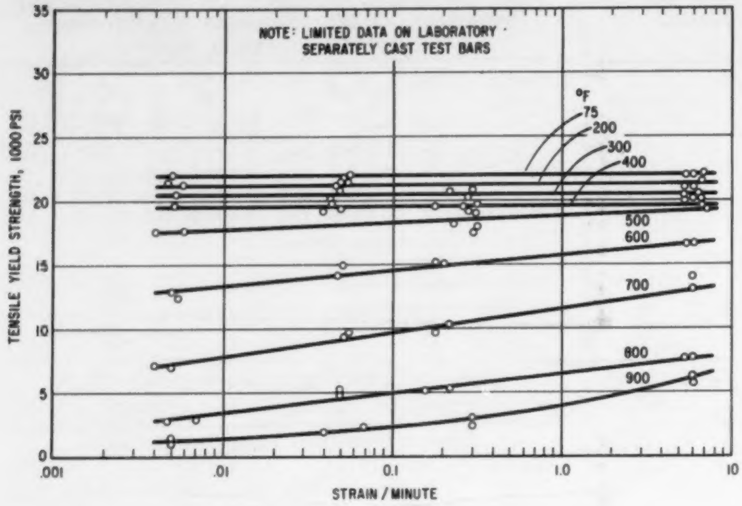

Fig. 7 — Strain rate effect on yield strength of sand cast EK31XA-T6 alloy.

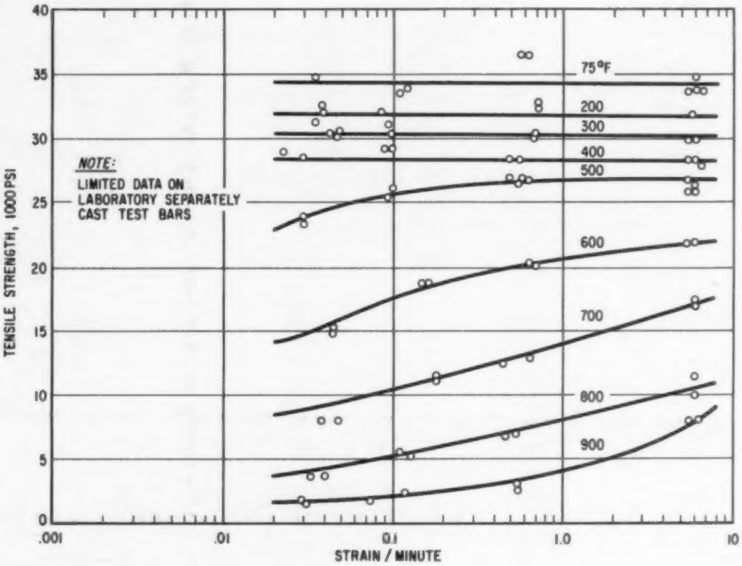

Fig. 8 — Strain rate effect on tensile strength of sand cast EK31XA-T6 alloy.

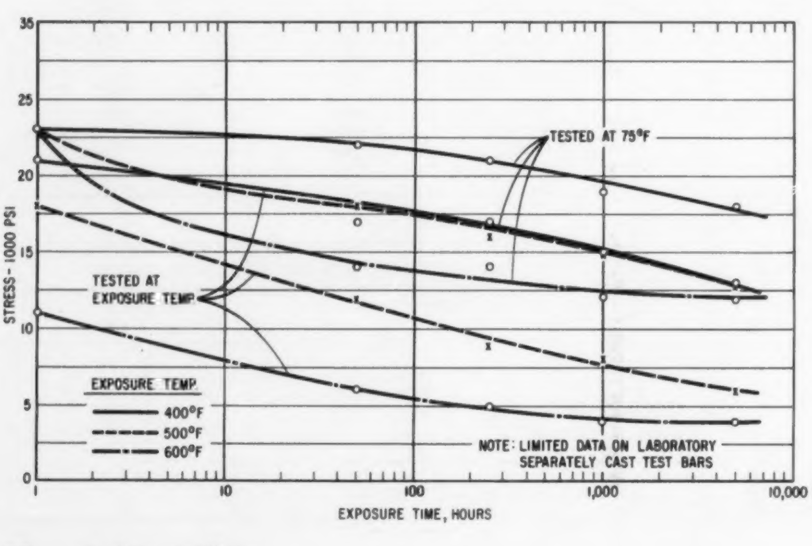

Fig. 9 — Exposure effect on yield strength of EK31XA-T6 alloy at 75, 400, 500 and 600 F.

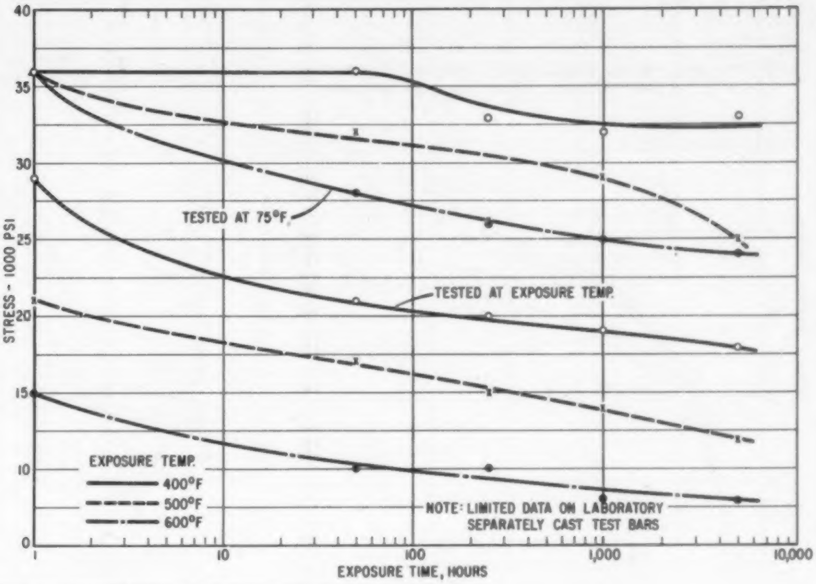

Fig. 10 — Exposure effect on tensile strength of EK31XA-T6 alloy at 75, 400, 500 and 600 F.

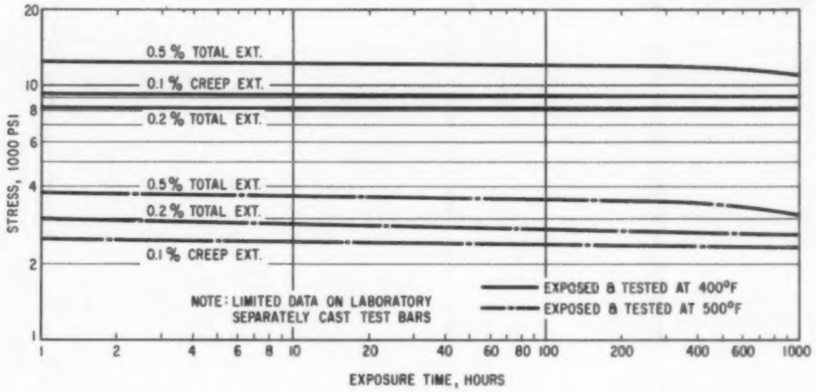

Fig. 11 — Exposure at elevated temperatures effect on 100 hr creep limits of EK31XA-T6 alloy.

loys in response to chemical treatment. The following treatments can be satisfactorily applied:

1) Chrome pickle (MIL-M-3171 Type I).
2) Galvanic anodize (MIL-M-3171 Type IV).
3) Sealed chrome pickle (MIL-M-3171 Type II).
4) Anodize (AMS 2478).
5) Anodize [(MIL-C-13335, (ORD) and AMS 2476)].

Dichromate treatment (MIL-M-3171 Type III) cannot be used on this alloy.

CONCLUSIONS

EK31XA alloy is classified in terms of castability with the magnesium-rare earth metal-zirconium alloys, even though limitations in design will be met with simpler castings in this alloy than with EZ33A alloy.

The excellent tensile properties at room and at elevated temperatures, as well as the good creep strength exhibited for short times (up to 10 hr), suggest EK31XA-T6 alloy will find applications in rockets and missiles. Its creep strength for times up to 1000 hr is favorable for applications operating up to about 450 F.

Standard procedures recommended for the chemical treatment of commercial sand-cast magnesium alloys can be used with EK31XA-T6 alloy. When properly chemically treated and painted, castings in this alloy should perform satisfactorily in service.

While this paper relates specifically to sand-cast EK31XA alloy, permanent mold castings should be readily prepared with properties equivalent to those reported herein.

A recommended composition range and heat treat-

TABLE 13 — BEARING, SHEAR AND HARDNESS VALUES FOR EK31XA-T6 SAND CASTING ALLOY

Testing Temp., F	Bearing Strength, 1000 psi* (3/16 in. Dia. Pin)	
	Bearing Yield	Bearing Ultimate
75	48	68
400	43	57
600	26	37
	Shear Strength, 1000 psi** (1/8 in. Dia. Pin)	
75	23	
400	19	
600	11	
	Rockwell "E"	Brinell (500 kg)
Hardness	74	63.8

*2d edge distance — 8d width.
**Double pin shear.
NOTE: These are limited laboratory data.

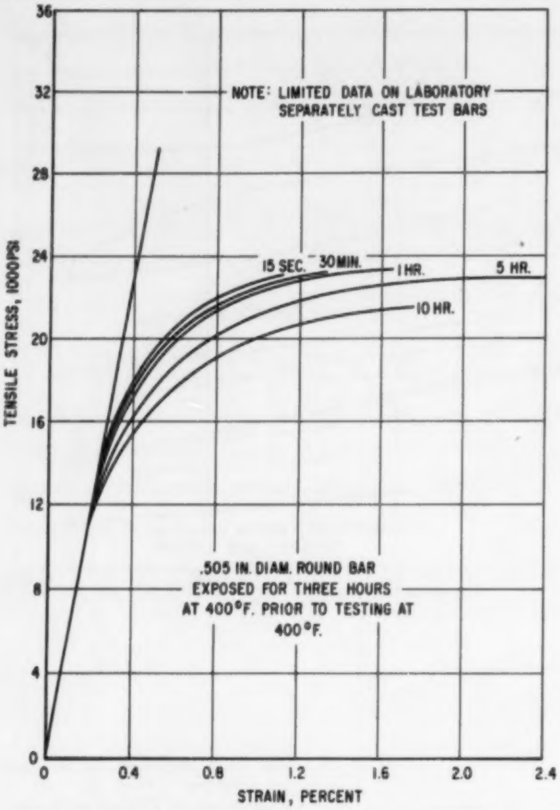

Fig. 12 — Isochronous stress-strain curves at 400 F for cast magnesium alloy EK31XA-T6.

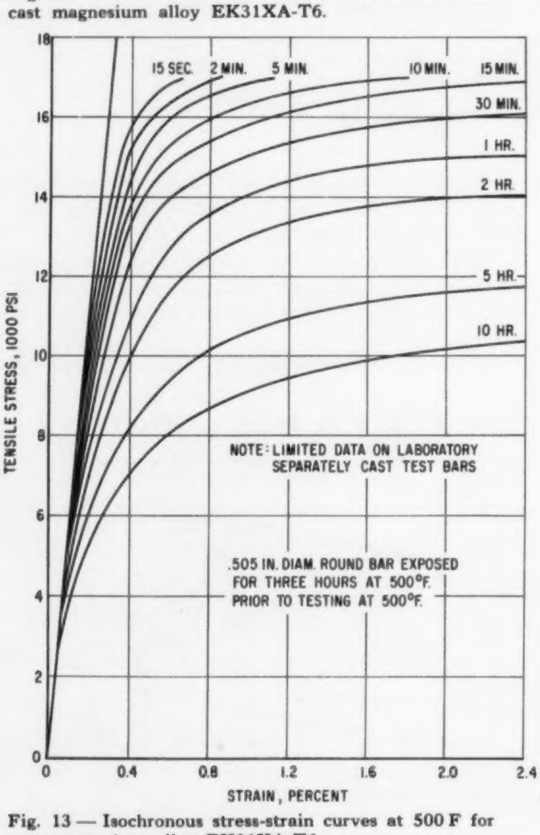

Fig. 13 — Isochronous stress-strain curves at 500 F for cast magnesium alloy EK31XA-T6.

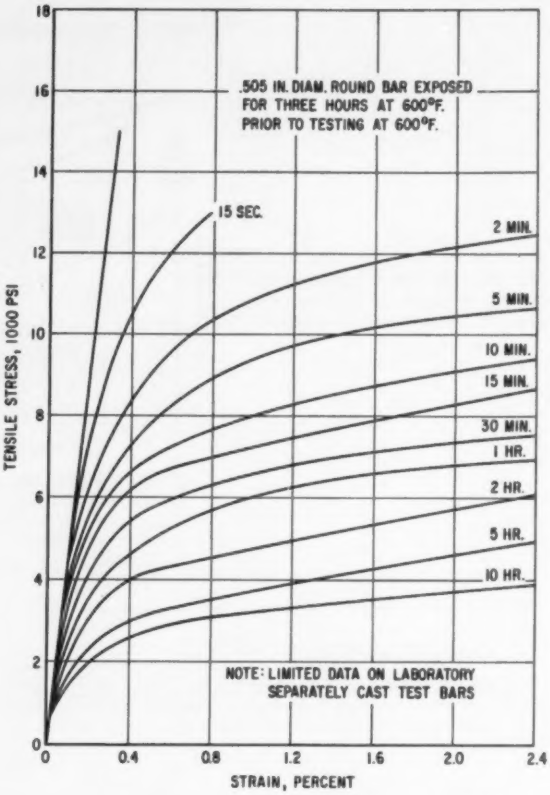

Fig. 14 — Isochronous stress-strain curves at 600 F for cast magnesium alloy EK31XA-T6.

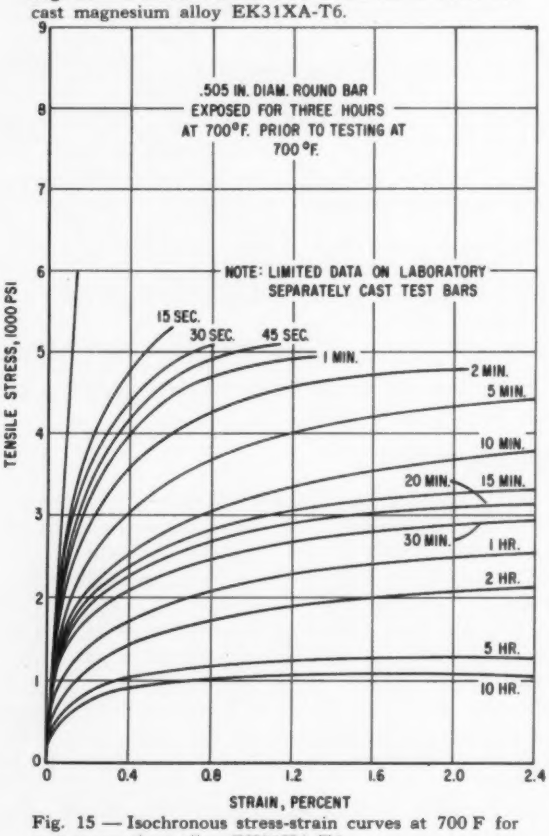

Fig. 15 — Isochronous stress-strain curves at 700 F for cast magnesium alloy EK31XA-T6.

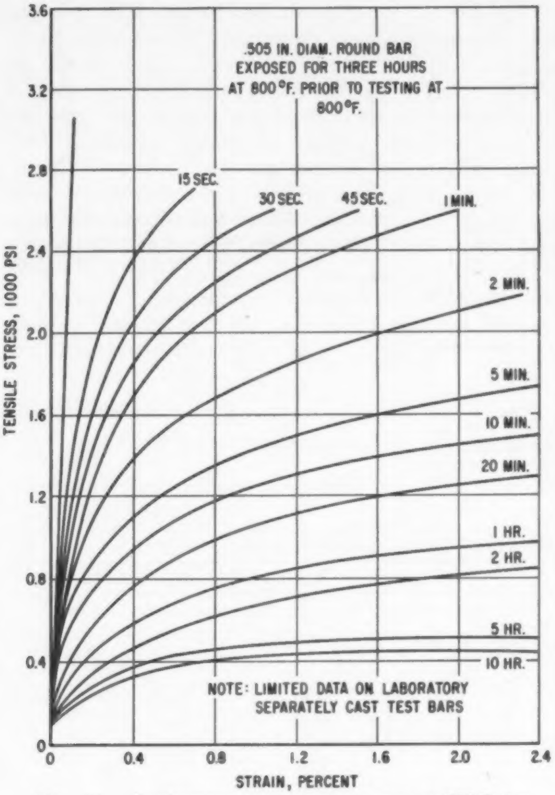

Fig. 16 — Isochronous stress-strain curves at 800 F for cast magnesium alloy EK31XA-T6.

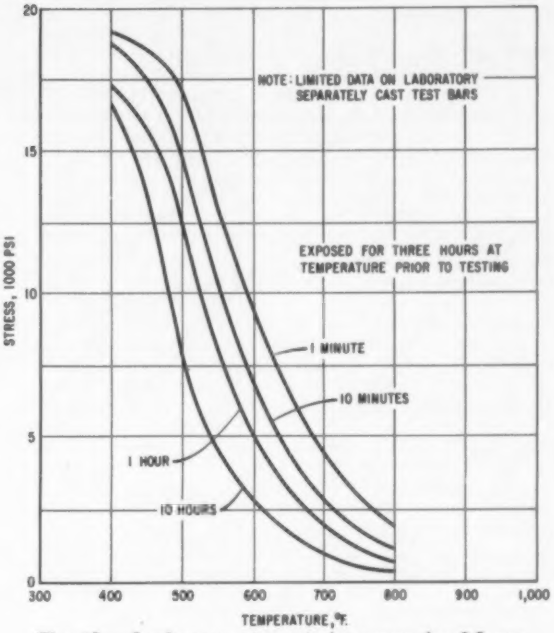

Fig. 17 — Isochronous stress-strain curves for 0.5 per cent total extension for cast magnesium alloy EK31XA-T6.

ment is given for EK31XA-T6 alloy in Table 1. Table 14 reports typical and guaranteed tensile properties of this alloy, and compares them with properties of other magnesium casting alloys.

APPENDIX A

PROCEDURE

Preparation of the molten alloy is similar to that used for the standard magensium casting alloys containing rare earth metals and thorium.[7,8,9] In these alloys, as in EK31XA alloy, serious losses of zirconium may be encountered if precautions are not taken to prevent contamination with harmful impurities such as aluminum and silicon. It can also be pointed out that contamination with cerium and lanthanum, such as found in mischmetal used in the commercial magnesium-rare earth metal alloys, could result in a lowering of properties.

Melts were prepared using either virgin materials or foundry run-around scrap with additions of didymium and zirconium to make up losses of these elements incurred during remelting. Didymium was added as a magnesium-didymium hardener analyzing between 10 and 15 per cent didymium. The total rare earth content as didymium and the zirconium con-

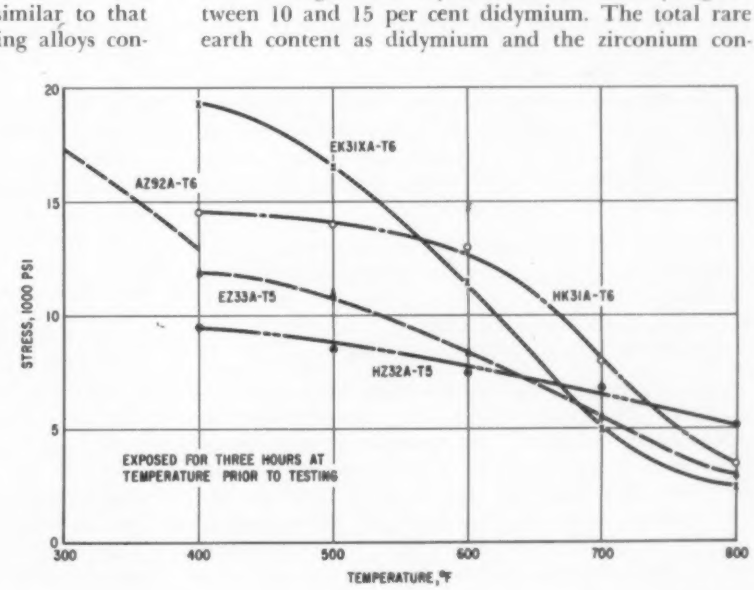

Fig. 18 — Comparison of various magnesium casting alloys isochronous stress-strain curves for 0.5 per cent total extension in a 15 sec test.

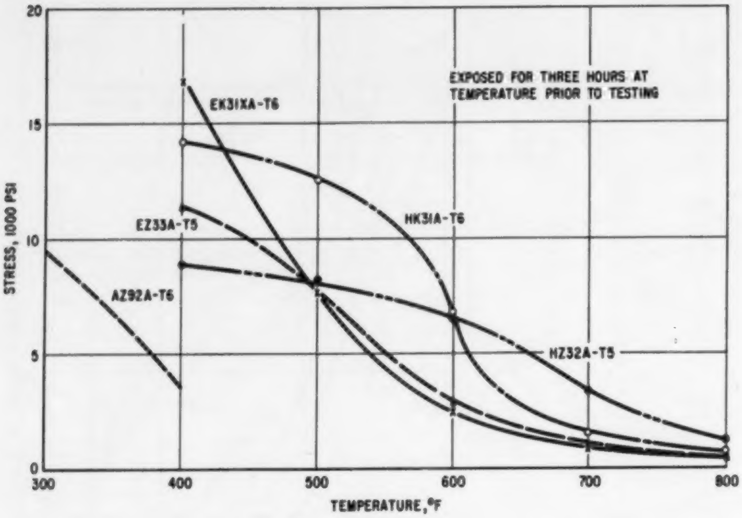

Fig. 19 — Comparison of various magnesium casting alloys isochronous stress-strain curves for 0.5 per cent total extension in a 10 hr test.

TABLE 14 — MECHANICAL PROPERTIES OF VARIOUS MAGNESIUM SAND CASTING ALLOYS

	Separately-Cast Test Bars										Bars Sectioned from Castings					
	TS		YS		E, %		Shear, 1000 psi.	Typical Bearing Strength 1000 psi		Brinell Hardness	TS		YS		E, %	
Alloy	Typ.	Min*	Typ.	Min*	Typ.	Min*	Typ.	Ult.	Yd.	No.	Ave.**	Min*	Ave.**	Min*	Ave.**	Min*
AZ92A-T6	40.0	34.0	21.0	18.0	2	Not req.	20	80	65	84	25.5	17.0	16.0	13.5	—	—
ZH62A-T5	40.0	35.0	25.0	22.0	6	4	23	72	49	70	31.5	26.5	17.5	15.5	1	—
EZ33A-T5	23.0	20.0	15.0	14.0	3	2	20	57	40	50	15.0	13.0	12.5	11.0	0.5	—
HK31A-T6	32.0	27.0	15.0	13.0	8	4	21	61	40	55	23.0	19.0	11.7	10.5	1	—
HZ32A-T5	30.0	27.0	14.0	13.0	7	4	20	60	37	57	23.0	19.0	11.7	10.5	1	—
EK31XA-T6	35.0	31.0	22.0	19.0	4.5	2.5	23	68	48	64	26.0	22.5	17.5	16.5	1.0	—

TS = Tensile strength, 1000 psi.
YS = Yield strength, 1000 psi.
E, % = Elongation in 2 in.

*Guaranteed properties based upon one test.
**Guaranteed properties based upon four to ten tests.

NOTE: Guaranteed properties on EK31XA-T6 are tentative.

tent were analyzed by wet chemical methods,[10] with the zirconium contents being reported as "soluble," indicating that portion soluble in dilute acid solution. The usual impurities in each melt were determined spectroscopically.[10]

A casting intended to evaluate sensitivity of alloys to the formation of surface sinks, draws and porosity as well as slope castings[11] were used in conjunction with castings poured in the production foundry in order to evaluate castability. Four castings were prepared in the production foundry:

1. Casting A, 86-lb housing used on helicopters.
2. Casting B, 14-lb airframe component used on helicopters.
3. Casting C, 10-lb jet engine casting.
4. Casting D, 30-lb aircraft wheel casting.

These castings vary in wall thickness from 0.200 in. to 2.0 in. The gating and risering methods used on these casting designs for the commercial magnesium-rare earth metal-zirconium alloys were applied to EK31XA alloy. Standard separately-cast test bars, ½-in. diameter, were also cast from the melts used to pour these castings. The grain sizes were determined by the comparison method described by George.[12]

The castings were inspected in the usual way for foundry defects. Heat treatments were performed in both laboratory and production furnaces. The solution heat treatments were done in a protective atmosphere of air plus greater than 1 per cent SO_2 gas. The parts were then quenched as described in this paper. Precipitation heat treatement was done in regular furnace atmospheres.

After heat treatment the slope castings were sectioned, as described by Pearson,[11] while the other castings were sectioned as completely as possible from thick and thin sections, in order to obtain a complete picture of their room and elevated temperature tensile properties and elevated temperature creep strength. These sections were machined to conform to standard A.S.T.M. specified shapes for testing, or, when this was not possible, to dimensions listed as acceptable to the A.S.T.M.

Standard separately-cast test bars were used in determining effects of exposure at elevated temperatures on the room temperature and elevated temperature tensile properties of this alloy. Creep tests of 100 hr were made using separately-cast test bars. These tests were performed after exposures without applied stress for various times at elevated tempera-

tures. The exposure treatments were carried out in electrically heated Laboratory furnaces controlled to ± 5 F.

Tensile,[7,13] creep,[7,14] bearing[15] and shear[16] strength determinations have been described. Fenn and Gusack[17] report on methods of obtaining effects of strain rate on tensile properties, while Fenn[18] describes the determination of room and elevated temperature modulus values. Clapper[19] describes procedures for obtaining short-time creep data and the plotting of isochronous (equal-time) stress-strain curves for each test temperature. Alternate immersion testing in 3 per cent NaCl solution has also been described.[20]

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STRUCTURAL VARIABLES INFLUENCING MECHANICAL PROPERTIES OF HIGH STRENGTH CAST STEELS

a progress report

By M. C. Flemings, R. Green and H. F. Taylor

ABSTRACT

The initial phase of what is planned as a continuing study into the effect of solidification variables on the structure and properties of high strength cast steels is described. Plate castings of a modified 4330 alloy were cast in several different molding materials to obtain widely varying conditions of solidification. Cooling rates during solidification (at test bar locations) were varied from 300 F to less than 20 F/min. Thermal gradients during solidification were varied from 350 F to less than 70 F/in.

The differences in solidification conditions did not affect the macrostructure (columnar, original austenite grains) appreciably, but changed the microstructure in important ways. The internal structure of the dendrites became much finer with increasing cooling rate; also increasing cooling rates resulted in finer, more evenly distributed inclusions. Slow cooling rates tended to result in coarser agglomerated inclusions. Voids (microporosity) were evident in the central portion of all plates; the voids were most marked in an unchilled casting poured in dry sand.

Mechanical properties (including tensile and impact) were measured in various locations in the plates solidified under different thermal conditions. Properties were measured in the quenched and tempered condition. Tensile and yield strengths were essentially constant in all plates, but large variations in values of elongation and reduction of area were obtained depending on solidification conditions. These variations were attributed to differences in 1) microporosity, 2) microsegregation and 3) inclusion size and distribution.

As a quick check upon the effect of the most drastic conditions of chilling, a brief investigation was made of the structure and properties from metal melted by arc welding and then allowed to rapidly re-solidify.

INTRODUCTION

At present, high strength steel castings of a reasonably high degree of intricacy are obtainable from a few specialized steel foundries; these castings possess tensile strengths of the order of 200,000 psi, and have adequate ductility and impact strength for Ordnance applications. The production of intricate, thin walled castings with tensile strengths approaching 300,000 psi appears to be a practical possibility in the near future, and strengths in excess of this may someday be feasible (again with adequate ductility and impact strength).

Design engineers and metallurgists have not overlooked the potentialities of such high strength castings, and there is a growing demand to 1) develop techniques for producing steel castings with higher tensile strengths, while retaining adequate ductility and impact strength and 2) develop techniques which make it practical to cast more complex shapes in high strength steels.

Many of the problems presently encountered in producing high strength steel castings are related to the solidification mechanism of the alloy; these include hot tearing, shrinkage defects, some surface defects and segregation of nonmetallics and alloying elements. It should be possible to reduce or eliminate these problems by scientific control of the mode of solidification, together with careful control of such variables as melt chemistry, melting practice and heat treatment.

Results reported herein describe the first year's work at M.I.T. on solidification of high strength steel under simulated production conditions. This is a progress report of a continuing investigation supported by the Ordnance Department through Rodman Laboratory, Watertown Arsenal.

Studies to date have been concentrated primarily on the effect of mode of solidification on 1) microsegregation, 2) microshrinkage and 3) inclusion count and distribution. Solidification variables were 1) cooling rate and 2) thermal gradients. Tensile and impact properties were measured on test bars solidified under various thermal conditions. Results of these investigations, together with a survey of the literature are reported herein.

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LITERATURE SURVEY

Solidification and Segregation of Low Alloy Steel Castings

Microsegregation. Low alloy steel castings solidify, as do all cast alloys, by the formation and growth of dendrites. As the dendrites grow, carbon and other alloying elements are segregated into their liquid interstices and between the arms of individual dendrites. When, finally, the last metal freezes in the interstices of the dendrites, this metal contains the richest concentration of alloying elements. This micro-scale inhomogeneity is termed "microsegregation," or "coring."

Depending on thermal gradients during solidification and on nucleation,[1] the structure of any portion of a steel casting may be either of columnar or equiaxed dendrites, but the "coarseness" of each individual dendrite (distance between dendrite arms) is dependent only on rate of solidification.[2] A relatively coarse structure is obtained within individual dendrites when cooling is slow; when cooling is more rapid the dendrites consist of many more branches and sub-branches, and their internal structure is much "finer."

Thus, it is to be expected that the microstructure at the center of a large steel casting should be considerably different from that at the surface, and should also differ from the microstructure of a relatively thin casting; this has been observed experimentally by numerous investigators.[3-7]

Macrosegregation. Another type of segregation which can occur in steel castings is macrosegregation. This is the bulk movement of alloying elements from the surface of the casting towards the center ("positive" segregation), or the bulk movement of alloying elements from the center of a casting towards the exterior of the casting ("negative" segregation). It has been shown that in steel castings up to about 8 in. in section thickness, macrosegregation of elements other than carbon is negligible.[6,8] The segregation of carbon is usually slight and negative,[6,8] except under specialized conditions of solidification.[9]

Microsegregation Effect on Mechanical Properties

Carbon diffuses extremely rapidly in iron at elevated temperatures, and so in plain carbon steels simple austenitizing treatments are probably adequate to eliminate significant microsegregation. In low alloy steels, elements other than carbon segregate (including chromium, nickel and molybdenum); these elements diffuse much less rapidly than carbon, and so microsegregation in low alloy steels is quite difficult to eliminate by subsequent heat treatment.

Even after homogenization treatments at quite high temperatures, concentration gradients often remain in low alloy steels; these gradients (microsegregation) may have important effects on the hardenability and mechanical properties of a steel casting.[7]

When coring remains after heat treatment, the alloy-poor areas in the center of dendrite spines are not as hardenable as the dendrite surfaces, and may therefore decompose to high temperature constituents of iron carbide while the alloy-rich areas will transform entirely to martensite. Other microstructural effects are also possible, depending on the composition of the steel and on the specific heat treatment employed.[10-12]

Mechanical properties which are likely to be affected to the greatest extent by any variation in microstructure are ductility, reduction in area, impact strength and the yield-tensile ratio.[11] For example, Hollomon and Jaffee[13] have shown the importance of having a fully tempered martensitic structure to assure good notch-bar impact properties and a high yield-tensile ratio.

In any cast alloy system, the coarse dendritic structure obtained by slow cooling is less amenable to homogenization treatment than the finer structure obtained by rapid cooling.[6,14] Thus, it is to be expected that the central portions of a steel casting would exhibit lower mechanical properties than the exterior of the casting due to microsegregation effects alone. A number of investigators[6,8,15,16,17] have shown that mechanical properties (particularly reduction of area and elongation) are lower in heavy cast steel sections than in light sections.

Section Size Effect

However, it is not always possible to attribute these variations in mechanical properties directly to variations in microsegregation or to changes in any other single variable, since many factors are affected by increasing section size (or by different locations within a section). These include, microsegregation, macrosegregation, porosity, variation in inclusion count and distribution and effect of section size on heat treatment variables.

Studies of the effect of increasing homogenization temperatures and times on the mechanical properties of cast steels of various section sizes are one direct indication of the importance of microsegregation in determining properties of a cast steel (since the only beneficial effect of these treatments is considered to be the minimization of the microsegregation). Instances[18-20] have been cited where no change in hardenability was observed after increasing homogenizing times and temperatures, and no appreciable change in mechanical properties resulted. In other cases,[7,21] however, increased homogenization temperatures have been found to be definitely beneficial to mechanical properties of steels.

In work by Wallace, Savage and Taylor,[6] comparative mechanical properties were determined at the center and the surface of a large steel casting (5 in. in diameter). Substantially lower properties were obtained in the center of the casting than at the surface, and these lower properties were attributed to 1) microsegregation and 2) agglomeration of inclusions at the center. By inserting a thin core at the center of their casting around the location of the central test bar, transfer of metal from the central test bar to the exterior of the casting was prevented.

The core prevented agglomeration of inclusions at the center, and increased the tensile strength of the central specimen. Although tensile ductility was improved by the use of the core it still remained appreciably less than that in the outer areas. This

was taken as an indication that the interdendritic segregation due to the slower cooling rate was, of itself, deleterious to the mechanical properties of the cast steel.

Solidification and Microporosity

Another feature of the solidification process which may have a bearing on the properties of cast steel is porosity. As freezing progresses, it sometimes becomes difficult for liquid metal to feed into the voids which form as a result of solidification contraction. These voids may exist as large cavities or as a series of smaller voids between adjacent dendrites. The latter form of porosity is particularly pronounced in alloys which freeze with a wide liquid-solid zone ("mushy" zone). Also, gas which is liberated upon solidification of the metal exerts a positive pressure in the liquid channels and hinders feeding.[22]

If the cavities thus formed in cast steel are disposed along the centerline and are visible to the naked eye they are termed "centerline shrinkage;" finer, more randomly dispersed porosity is variously called "interdendritic shrinkage," "microshrinkage" and "microporosity."

Bishop and Pellini[23] have outlined the factors affecting centerline shrinkage in steel castings, and methods for elimination of this shrinkage. For example, they have shown that it is possible to feed a 1 in. thick plate which is 4½ in. long if a riser is placed at one end of the plate. The plate so risered is sound to within commercial nondestructive radiographic practice; i.e., 2 per cent definition.

The design rules formulated by Bishop and Pellini, therefore, provide for elimination of centerline shrinkage but do not necessarily guarantee complete absence of microporosity. In fact, it has been shown by Walther, Adams and Taylor[24] that to eliminate microporosity completely may require quite high thermal gradients during solidification.

The importance of microporosity upon the mechanical properties of steel castings is not well understood. Briggs and Gezelius[8] have attributed the low mechanical properties at the center of heavy cast steel sections to several factors, one of these being "low density." They do not, however, definitely attribute the low density to the presence of porosity. Several recent investigations[21,25] have shown that microporosity can affect tensile ductility seriously.

Whether or not microporosity is present to any marked degree in well fed steel castings is, however, a matter that has received little attention from investigators. At present, the most that can be said is that to minimize the effect of microporosity, casting design should be such as to insure that directional solidification takes place.[25]

Solidification and Inclusions

The effect of sulfur and phosphorus in lowering the elongation, reduction of area and impact properties is widely known. Sulfur is especially deleterious to these properties, and whenever possible the sulfur level of high strength steels should be kept below 0.01 per cent.[21] The damaging effect of sulfur is apparently due to formation of sulfide inclusions which, along with inclusions of oxides, silicates and occasionally nitrides or carbonitrides, are found at grain boundaries in cast steel. The form and type of these inclusions are strongly influenced by the deoxidation practice used.

Sims and Dahle[26] were the first to correlate inclusion characteristics with the degree of deoxidation employed. They classified inclusions into three types, 1, 2 and 3. Type 2 inclusions are a form of grain boundary "stringers" which seriously reduce ductility and impact strength and which are undesirable in cast steel; Types 1 and 3 are more globular in nature and less deleterious to properties.

Type 1 inclusions are most favorable for optimum mechanical properties, but melting practices which achieve these inclusions usually do not completely deoxidize the steel. Type 3 inclusions are only slightly less desirable than Type 1, and it is this type of inclusions that is sought in most melting practices. The effect of various deoxidation practices on inclusions and properties of cast steels have been summarized in a recent paper by Sims,[27] and the theory underlying these effects are given in an earlier paper by the same author.[28]

Wallace, Savage and Taylor[6] have shown that the size and distribution of inclusions are affected not only by the melting practice but also by solidification variables. They found that while inclusions at the exterior of their heavy (5 in. diameter) steel castings were fine and randomly dispersed, inclusions at the center tended to be coarser and to agglomerate (frequently in chain-like arrangements).

High Strength Steels

The past decade has seen a tremendous increase in the need for high strength steel castings as well as forgings.[29,31] However, research efforts on high strength steels have been confined for the most part to the alloying and heat treatment of forged steels,[28-30] and only limited work has been carried out with cast steels.[21,32]

Probably the first approach to high strength steels (in forgings) was to employ the standard 4340 analysis but to temper it at 400 to 450 F instead of the standard tempering treatment in excess of 800 F. By doing so, the strength level was advanced from 190,000 to 270,000 psi in a single step.[28] However, most high strength forged steels in use today have been tailored to provide increased strength with little or no decrease in established values of ductility and toughness; essentially all cast alloys have also been "tailor-made" to these ends.

In development of compositions and heat treatments for low alloy steel, it has been necessary to avoid tempering the quenched steel in the so-called "500 F embrittlement range." When impact test values are plotted against tempering temperature, impact strength is usually a minimum near 500 F, although by the addition of silicon the embrittlement range can be raised to over 700 F.

Some steel analyses employ silicon additions to permit tempering at temperatures as high as 600 F, to allow more complete relief of residual quenching stresses with consequent improvement in yield strength and ductility. Typical modifications of com-

TABLE 1 — CHEMICAL ANALYSES OF EXPERIMENTAL HEATS

Heat	Modified 4330 Analyses							
	C	Mn	Si	Ni	Cr	Mo	P	S
A	0.27	1.12	0.57	1.80	0.93	0.42	0.006	0.012
B	0.24	1.20	0.62	1.79	0.91	0.41	0.007	0.009
C	0.26	1.08	0.58	1.79	0.90	0.40	0.009	0.009
D	0.28	1.12	0.59	1.83	0.94	0.41	0.007	0.009
E	0.27	1.10	0.56	1.80	0.90	0.41	0.008	0.011
F	0.28	1.15	0.42	1.91	0.96	0.42	0.007	0.009
G	0.29	1.12	0.51	1.87	0.96	0.43	0.010	0.017
Aim	0.27	1.10	0.55	1.85	0.90	0.40	—	—

positions of alloys of the 4300 series for casting purposes are given in recent research publications on the subject.[21,32]

SCOPE OF WORK

Work reported herein has concentrated primarily on a study of the effect of solidification variables on 1) microsegregation, 2) microshrinkage and 3) inclusion count and distribution. The solidification variables which were measured and controlled were cooling rate and thermal gradients. Most of the work reported has been carried out by study of simple ¾-in. plate castings, end risered. High strength steel was employed, and a variety of molding materials (plus metal chills) were used to obtain different solidification conditions.

Castings were poured in 1) end chilled zircon sand mold, 2) end chilled dry sand mold, 3) dry sand mold without chill, 4) ethyl silicate bonded mullite mold without chill at room temperature, 5) ethyl silicate bonded mullite mold without chill heated to 125 F and 6) ethyl silicate bonded mullite mold without chill heated to 1600 F.

In one portion of the investigation, some of the high strength alloy was solidified rapidly by freezing a weld bead; microstructures and mechanical properties were examined.

The alloy analysis was modified 4330 with a nominal analysis as shown in Table 1. All specimens were quenched and tempered, and the tempering treatment was designed to produce a strength level of approximately 200,000 to 210,000 psi. Thermal analyses of the solidifying castings were made to determine cooling rates and thermal gradients during solidification. Sections from the plates were examined by metallography and microradiography, and tensile and impact test bars were taken from different locations of the plates. The experimental program was designed to determine the inter-relationship between thermal variables, structural variables and mechanical properties.

The plan of research follows that of a similar undertaking at M.I.T. (under sponsorship of U. S. Army Ordnance, Pitman-Dunn Laboratories, Frankford Arsenal) to determine why maximum mechanical properties were not being obtained in aluminum alloy castings; by isolating the effects of such variables as gas content, soundness, thermal gradients and solidification rates, and by developing practical means for insuring optimum conditions of solidification the tensile strengths of aluminum alloy castings were doubled and their ductility increased several hundred per cent.[22] It is expected similar practical improvements in the properties of steel castings will ultimately accrue from this investigation.

PROCEDURE

Plate Pattern Studies

Molding and Melting. The test pattern in this study was a 7 x 5 x 1 in. plate with a 3 in. diameter riser positioned over one end (Fig. 1). The dimensions of the plate and location of the riser were such that all plates were expected to be sound by x-ray to at least 2 per cent definition.[23] Exothermic sleeves, of dimensions shown in Fig. 1, were used around the riser to aid feeding, every effort being made to insure a sound casting. A circular downsprue was used with a 2:1:1½ gating ratio. In the chilled plates, a water cooled steel chill 6½ x 1½ x 1¼ in. was positioned, as shown in Fig. 1.

Molding materials used were zircon sand, silica sand and ethyl silicate bonded mullite refractory, the ethyl silicate mix being that of a proprietary process. These molding materials were chosen to gain a range of mold chilling (or insulating) properties. Heats poured are listed in Table 2.

Thermal analysis was performed (during solidification) on five castings to determine the effects of the different mold materials on the progress of solidifica-

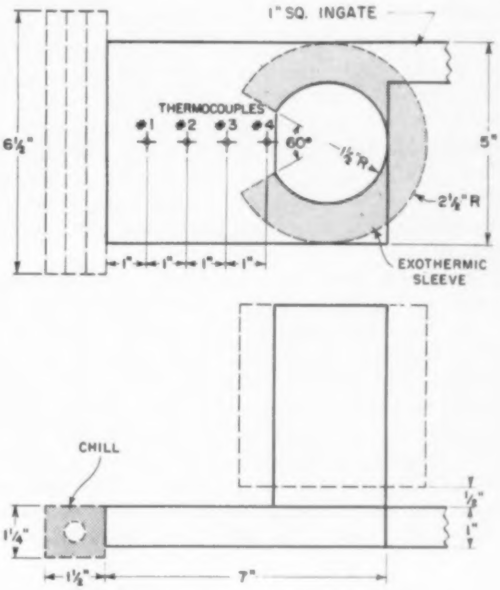


Fig. 1 — Sketch of test pattern with locations of thermocouples.

TABLE 2 — SUMMARY OF PLATE HEATS POURED

Heat	Mold Material	Mold Preheat Temp.	Rigging
A	Dry Zircon Sand	Room	Chilled
B	Dry Silica Sand	Room	Chilled
C	Dry Silica Sand	Room	Unchilled
D	Ethyl-silicate-mullite	Room	Unchilled
E	Ethyl-silicate-mullite	1250 F	Unchilled
F	Ethyl-silicate-mullite	1600 F	Unchilled
G	Dry Silica Sand	Room	Chilled

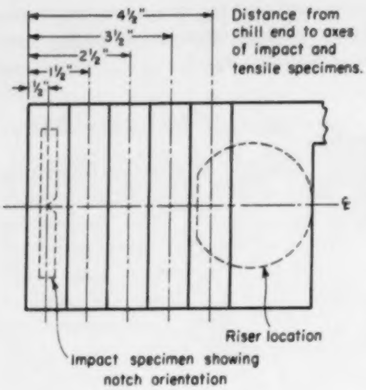


Fig. 2 — Location of tensile and impact test bars in plate pattern.

tion. Thermal data were obtained by placing thermocouples in the mold cavity, in locations shown in Fig. 1. Four plate castings were poured in each heat (except *E* and *F*, in which only two castings were poured). All castings in each heat were rigged identically; one casting was used for thermal analysis and the remainder were used for physical or mechanical testing.

A modified 4330 analysis was chosen as a typical high strength steel for purposes of this work, the 4330 analysis being modified principally by raising the silicon and manganese levels. Table 1 lists the aim analysis employed, and the analyses of each heat.

High Purity Melting Stock. All heats were made from high purity virgin melting stock and alloys. Electolytic iron was used for all heats except heat *G* (in order to reduce the sulfur and phosphorus levels to a minimum). Armco iron was used for heat *G*. The carbon was supplied by a carbon alloy previously made from armco iron and cabot coke. Calcium-manganese-silicon alloy plus aluminum were the deoxidizers used.

Melting was done in a magnesia lined induction furnace, and a ladle with a rammed magnesia lining was used for pouring. The charge consisted of iron (electrolytic or armco), nickel squares and ferromolybdenum. At meltdown ferrosilicon was added followed by the carbon alloy and ferrochrome. Ferromanganese was added at 3020 F after the slag was removed. Another ferrosilicon addition was made immediately prior to tapping at 3100 F. The heat was tapped into the calcium-manganese-silicon deoxidizer in the ladle, and the aluminum deoxidizer was plunged into the metal in the ladle at two-thirds tap. Molds were poured immediately after tapping.

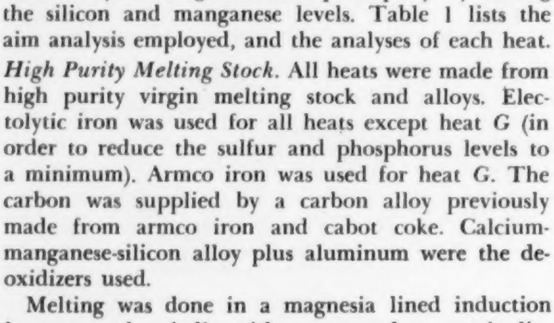


Fig. 3 — Location and macro and microradiography specimens.

Heat Treatment and Testing. The plates used to provide tensile and impact specimens were cut into 1 in. square bars before heat treating (Fig. 2). Since the purpose of this work was to determine the effects of varying solidification rate, no effort was made to maximize the strength levels obtained through heat treating; the following heat treating schedule was used for all test bars:

Solution 1800 F, 2 hr, air cool.
Harden 1650 F, 2 hr, oil quench.
Temper 700 F, 2 hr, air cool.

The 700 F tempering treatment was chosen to be just above the region expected to produce low impact properties.

All test castings were x-rayed before any sectioning was done, and proved to be sound at 2 per cent definition. Test bars for tensile and impact specimens were then cut parallel to the end furthest from the riser, in locations shown in Fig. 2. Standard 0.505 in. diameter tensile test specimens with a 2 in. gage length were machined from one plate in each heat. Standard ⅜-in. square notched impact specimens were made from a second plate casting in each heat. The location of the impact specimens corresponded to those of the tensile specimens, and the notch of the impact bars was made perpendicular to the plane of the plate (Fig. 2).

Tensile strength, yield strength, per cent elongation, per cent reduction in area and hardness were measured from the tensile specimen, the yield strength being obtained by 0.2 per cent offset method with a recording extensometer. The impact tests were made at −20 F.

Microscopic Examination. Microstructures were examined in the as-cast and heat treated condition. The specimens used to obtain the heat treated microstructures were prepared from the impact bars after they were broken; the location of the specimens being approximately ⅛-in. from the notch. The as-cast microstructures were taken in locations corresponding to the centers of the tensile and impact bars. These specimens were also used to show the inclusions present in the as-cast condition. Nital (1 per cent) was used to etch the heat-treated and as-cast specimens.

Macroscopic Examination. Cross-sections from the chilled end to the risered end were examined macroscopically to show the as-cast grain structure resulting from different rates of solidification. Figure 3 shows the orientation of the section examined. These specimens were etched with a 30 per cent (by weight) solution of ammonium persulfate applied at 90 F for 1½ min.

Microradiographic examination. Thin slices cut from cross-sections of plates in the as-cast condition were examined by microradiographic techniques. The orientation of these slices is shown in Fig. 3. They were approximately ⅛-in. thick as originally cut, and were then ground by taking equal amounts from both sides, until their thickness was under 0.020 in.

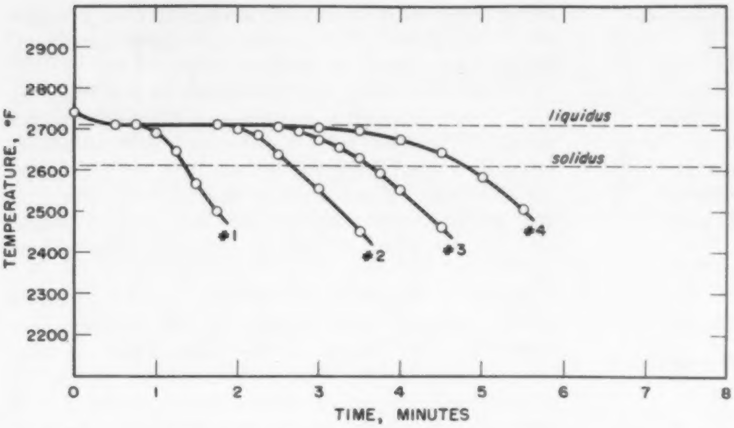


Fig. 4 — Cooling curves for plate cast in zircon sand, end chilled (heat *A*). Location of thermocouples shown in Fig. 1.

Grinding was done using a magnetic chuck (care was taken to keep the slice flat and of uniform thickness).

The slices were polished by hand with fine emery paper to remove the grinding scratches, and then x-rayed. With a thickness under 0.020 in., microscopic discontinuities such as interdendritic shrinkage are of sufficient size relative to the total thickness that a radiograph will show their presence.

Chemical analyses were obtained for each heat; these are given in Table. 1.

Ultra-High Solidification Rate Studies

Examination was made of the effect of extremely high solidification rates on the dendritic structure obtained in cast 4330 steel. The ultrahigh solidification rates were obtained by the melting and subsequent resolidification of a weld zone in a cast steel plate. Cooling rates (during solidification) obtained by this procedure were calculated to be approximately 700 F/min, as compared with maximum cooling rates in the chilled plates of about 300 F/min. Homogenization treatments of the structures so obtained have not been examined, but the effect of tempering temperature on hardness and bend test properties of the weld zone have been studied.

RESULTS AND DISCUSSION

Thermal Analysis

Cooling curves were obtained for each type of test plate casting made (zircon sand, end chilled; silica sand, end chilled; etc.). Figures 4 and 5 are representative of the curves obtained. Figure 4 presents thermal data for a plate cast in zircon sand, end chilled; and Fig. 5 presents data for a plate cast in a preheated ethyl-silicate mold. Cooling curves for the remaining plate castings may be found in the original report on which this paper is based;[33] however, Figs. 6, 7 and 8 summarize the important thermal data from the original curves.

Thermal analysis of early heats indicated that the liquidus of the alloy was at 2710 F and the solidus at about 2610 F. The liquidus temperature of some of the castings poured in the investigation showed minor deviations from 2710 F; when this occurred, the cooling curves were raised or lowered slightly so that the liquidus "hold" was moved to 2710 F. This was done to make it feasible to correlate thermal data from the various heats. In any event, even quite large deviations from the liquidus and solidus temperatures would not change the qualitative conclusions to be drawn from Figs. 6, 7 and 8 discussed hereafter.

Figure 6 compares the average cooling rate during solidification for various locations in the cast plate (at the centerline). In all castings the cooling rate through the solidification range is greater near the end farthest from the riser and decreases as the riser is approached. At a given location in the cast plates, the casting poured in zircon sand with an end chill

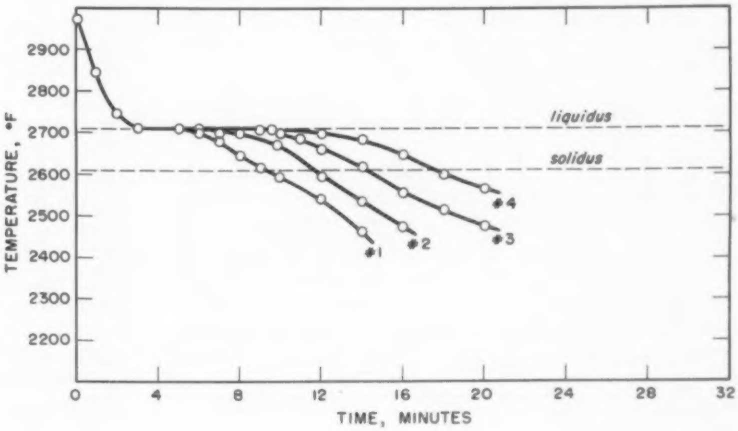


Fig. 5 — Cooling curves for plate cast in ethyl-silicate, no chill. Mold at 1250 F (heat *E*). Location of thermocouples shown in Fig. 1.

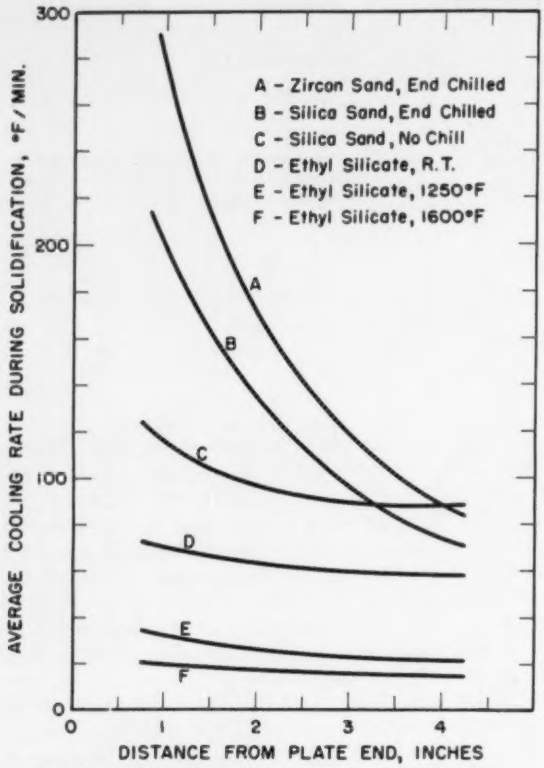


Fig. 6 — Average cooling rate during solidification (from 2680 F to 2610 F) as a function of location in the cast plates.

shows the greatest cooling rate during solidification; the casting poured in the hot ethyl-silicate mold shows the slowest cooling rate.

Average Cooling Rates

The cooling rates, shown in Fig. 6, are the average cooling rates between 2680 F and 2610 F. They were obtained from the original cooling curves by dividing the temperature difference 2680 F-2610 F by the time required for the metal to cool from the higher to the lower temperature (at a particular thermocouple location). The temperature 2680 F was arbitrarily chosen between the liquidus and solidus temperatures; the region from 2680 F to 2610 F is a region where liquid and solid coexist, but where substantial percentages of solid are already present.

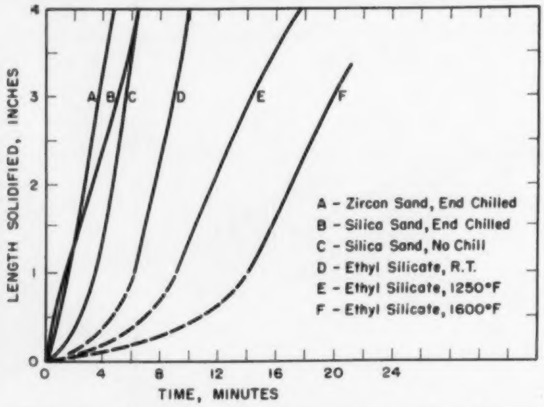


Fig. 7 — Progress of solidification as a function of time in the cast plates.

This cooling rate was calculated, rather than the cooling rate through the entire solidification interval, primarily because it is more easily and accurately obtainable from the thermal data. Also, earlier studies on aluminum alloys showed that thermal data for the last stages of solidification were more valuable for interpretation of casting structure and properties.[22]

Figure 7 illustrates the progress of solidification in the cast plates in a slightly different manner. The data show the length of the plate which is completely solid (at the centerline) vs. time; points for this curve are taken directly from the original cooling curves. Note that the interface between the fully solid material and the liquid-solid mixture ("mushy" zone) moves most rapidly in the case of the zircon sand mold, end chilled, and least rapidly for the unchilled ethyl-silicate mold (1600 F). In all cases, however, solidification is directional; that is, the completely solid interface moves progressively from the plate extremity towards the riser.

Thermal Gradients

It has been found that for some alloys[22] directional solidification, in the sense defined above, does not always insure a casting free of shrinkage defects. Thermal gradients must also be present in the liquid-solid

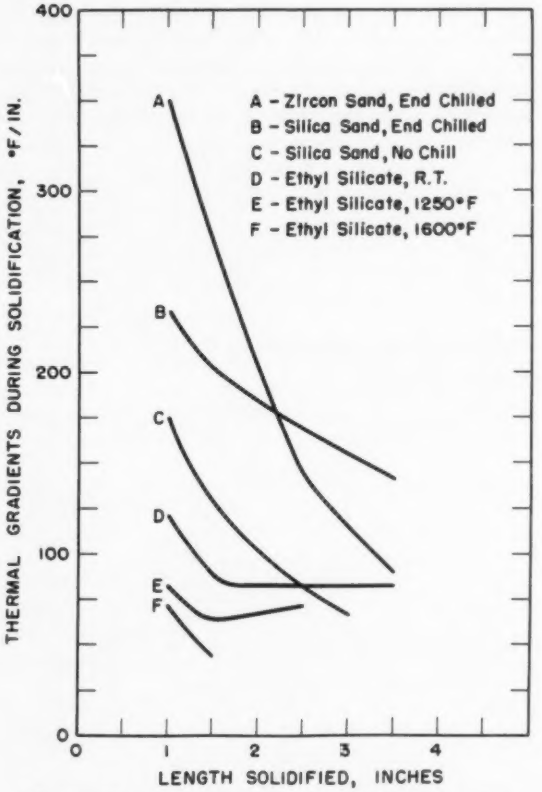


Fig. 8— Thermal gradients during solidification (between 2680 F and 2610 F) as a function of location in the plates. Length solidified is distance from the end of plate to the beginning of liquid-solid zone.

region of the solidifying casting. The gradients must be steep enough to maintain open feed channels so the liquid metal from the riser can flow easily through the interstices of the dendrites to accommodate solidification shrinkage.

Figure 8 illustrates these thermal gradients in the six different plate castings. The gradients are those existing at a particular location in the solidifying plate when that point is just completing solidification; they are the average gradients between 2680 F and 2610 F.

In Fig. 8, it may be seen that thermal gradients (near the plate extremity) are greatest for the zircon sand-end chilled casting and least for the ethyl-silicate (1600 F) casting. Near the riser, thermal gradients are steeper in the case of the end-chilled casting poured in silica sand than in the case of the end-chilled casting poured in zircon sand. They are also greater in the case of the casting poured in ethyl-silicate at room temperature than in the case of the unchilled casting poured in silica sand.

This rather unexpected result is undoubtedly due to the effect of the riser on thermal gradients. The heat effect of the riser should be felt to a greater extent when the molding material is more insulating.

Figure 8 was obtained by first plotting the progress of the solidus isotherm vs. time (Fig. 7). The progress of the 2680 F isotherm for each casting was then plotted on the same coordinate. Thermal gradients in the liquid-solid zone at any point in the casting were then readily calculated from the relationship

$$(\text{T.G.})_{\text{L}_1} = \frac{2680 - 2610}{\text{L}_2 - \text{L}_1}$$

where:

$(\text{T.G.})_{\text{L}_1}$ = thermal gradients at point 1 (F/in.)

L_2 = distance from plate extremity to 2680 F isotherm (in.)

L_1 = distance from plate extremity to 2610 F isotherm (in.)

As-Cast and Heat Treated Structures of Plate Castings

One casting each of Heats *A* through *D* were sectioned, as shown in Fig. 3, the cut surface polished and etched and the macrostructure examined. All castings were composed largely of columnar grains, the only major differences between the castings being that those that were end chilled exhibited a marked columnar zone which extended a maximum of about 1 in. from the chill face of the casting towards the riser.

In each of the four castings, microstructures in the as-cast condition were examined at intervals along the length of the plate. Microstructures at locations 1, 3 and 5 in. from the plate end are shown in Fig. 9. In the two end chilled castings, a large difference may be seen in the dendritic structure between the end near the chill and the end farthest from the chill, the finer dendritic structure being obtained near the chill.

Comparing the structures of the different castings, it is evident that as the molding material becomes more insulating, the dendritic structure becomes coarser (spacing between individual dendrite arms becomes greater). In general, a qualitative correlation is evident between the coarseness of the dendritic structure at any given location and the cooling rate of that location, as shown in Fig. 6.

Figure 10 illustrates the microstructures at the various locations in the plate after heat treatment. The homogenization treatment employed is observed to have been insufficient to completely homogenize any of the structures, including those quite near a chill. Hard, interdendritic areas of segregate remain, and these trace the same dendritic structure apparent in the as-cast condition.

Microporosity in the Plate Castings

Figure 11 shows sketches of microradiographs of sections approximately 0.020 in. thick, taken from four of the plate castings in the manner shown in Fig. 3. Microvoids are visible in all four of the castings shown. In the end chilled casting poured in a zircon mold few voids are apparent; these are in the region between about 3-4.5 in. from the plate end. In the casting poured in a silica sand mold, end chilled, voids are present between about 2.5 - 4.5 in., and these voids are somewhat more pronounced than those in the previous casting.

In the unchilled casting poured in silica sand, the voids are seen to be quite marked as compared with the previous two castings. They are present between about 2 and 4.5 in., and are present as elongated cavities between the columnar grains (extending almost to the plate surface in certain locations). In the case of the casting poured in the ethyl-silicate mold (room temperature), microvoids are again present between about 3-4.5 in., but these voids are fine and not well defined.

It has been concluded that the voids apparent in the microradiograph are microporosity. It is to be expected that the relative amounts of microporosity in the various castings should be related to the thermal gradients measured during solidification (Fig. 8).[22] Microporosity increases from the casting of Heat *A* to the casting of Heat *C* as would be expected since thermal gradients decrease in this order. However, the thermal gradients in Heat *D* are substantially lower then those of the preceding heats, but microporosity is generally less evident.

One reason for the lack of complete correlation between the steepness of the thermal gradient curves and the microporosity is the fact that thermal gradients could be obtained only up to about 3 to 3.5 in. In this region, little or no microporosity was observed in any of the castings.

Appearance of Inclusions

Figure 12 illustrates the appearance of inclusions in the cast plates of low sulfur content metal. The figure presents microstructures (at 300×) of three locations in each of four plates. Inclusions were all globular, and none were Type 2. In the two end-chilled castings inclusions were fine and well dispersed, although they became somewhat coarser near the riser. In the casting poured in silica sand, unchilled, inclusions were fine and well distributed

near the plate extremity, but remaining locations of the plate showed larger agglomerated inclusions.

Inclusions in the ethyl-silicate mold were also coarse as compared with inclusions in chilled sand plates. In general, it appears that rapid cooling rates result in finer, more evenly distributed inclusions; slower cooling rates result in coarser, agglomerated inclusions.

Figure 13 illustrates inclusions obtained in a heat of somewhat higher sulfur content than that employed in other heats (0.017 per cent sulfur, Heat *G*). Here, the deoxidation practice used yielded in-

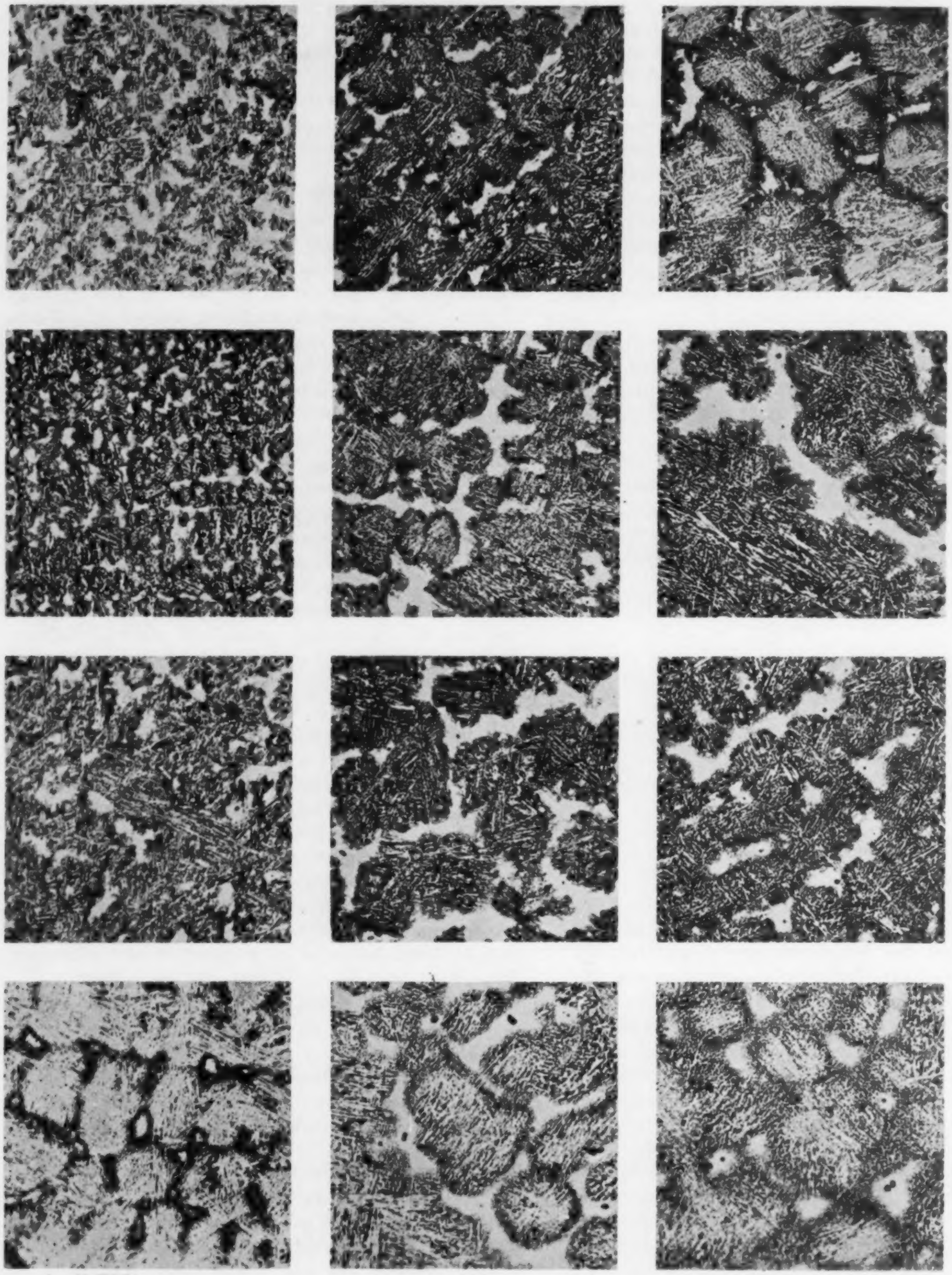
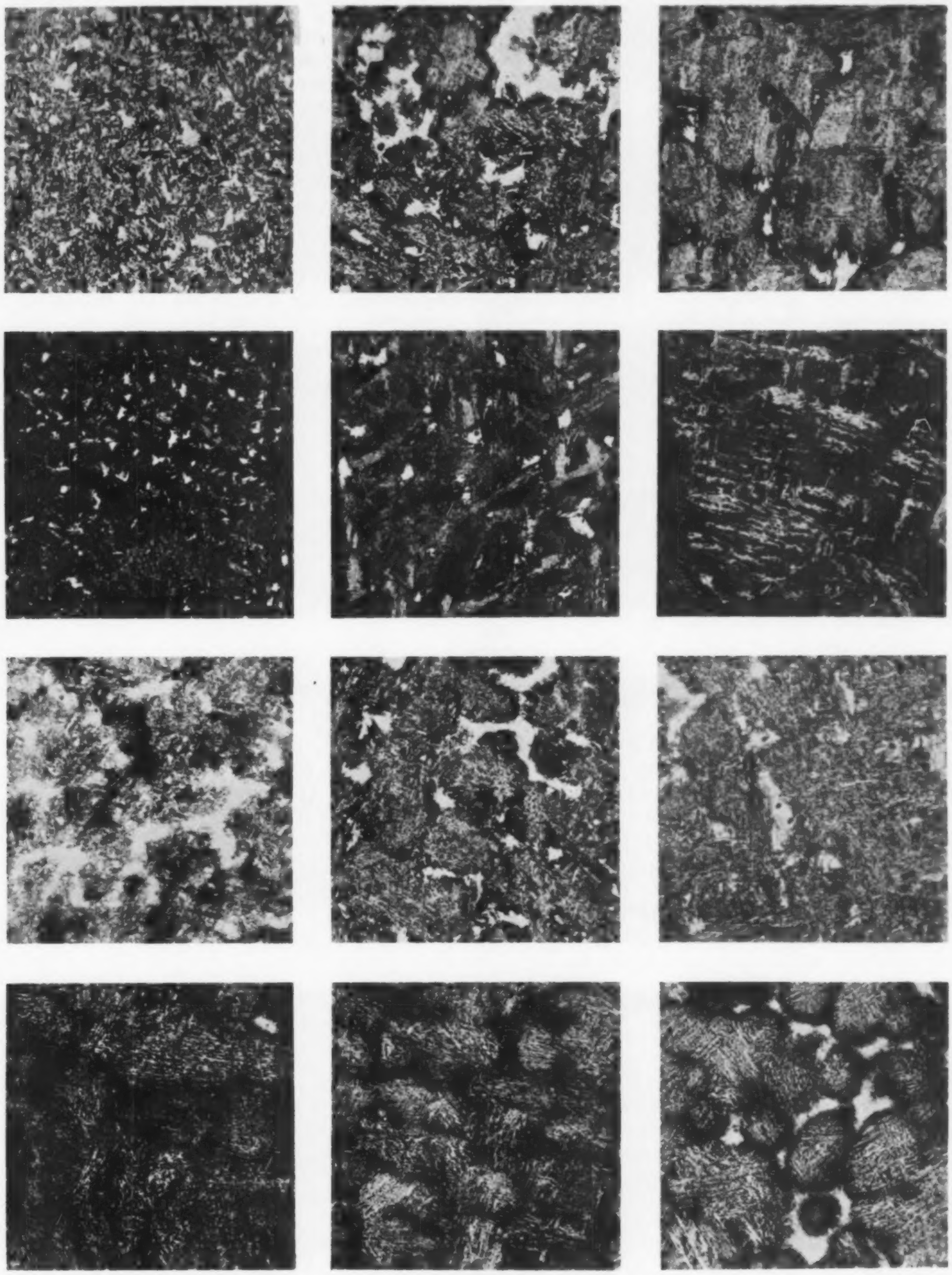


Fig. 9 — As-cast microstructures from test plates. Etched. 50 ×. Distance from plate end — *row 1*, 1 in.; *row 2*, 3 in.; *row 3*, 5 in. Horizontally — *row a*, zircon sand mold, end chilled; *row b*, silica sand mold, end chilled; *row c*, silica sand mold, no chill; *row d*, ethyl-silicate mold, no chill.

clusions of the unfavorable Type 2; the Type 2 films became somewhat coarser and stringier towards the riser end of the plate.

Mechanical Properties

Table 3 lists the mechanical properties obtained in the plate castings after heat treatment according to the schedule given earlier. The heat treatment employed was designed to produce a yield strength of approximately 180,000 psi, and an ultimate tensile strength of approximately 210,000 psi. Nearly all bars tested were 175,000-180,000 psi yield strength and 205,000-210,000 psi tensile strength. Elongation, reduction in area and impact strength varied markedly



a
b
c
d

1 2 3

Fig. 10 — Microstructures from test plate after heat treatment. Etched. 50 ×. Distance from plate end — *row 1*, 1 in.; *row 2*, 3 in.; *row 3*, 5 in. Horizontally — *row a*, zircon sand mold, end chilled; *row b*, silica sand mold, end chilled; *row c*, silica sand mold, no chill; *row d*, ethyl-silicate mold, no chill.

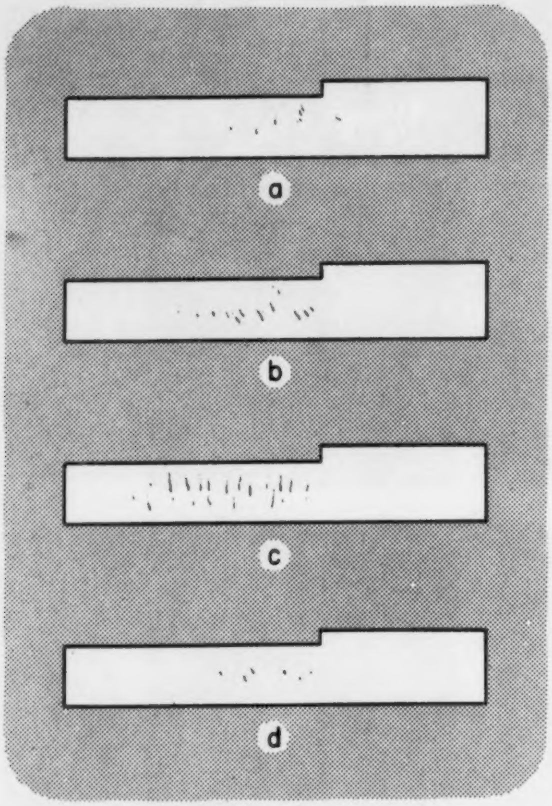


Fig. 11 — Sketches of microradiographs of sections cut from cast 1 in. plates. (a) zircon sand, end chill; (b) silica sand, end chill; (c) silica sand, no chill; (d) ethyl-silicate, room temperature. (The microradiographs are sketched for clarity as the voids are too fine to be reproduced through halftone screen).

depending on the type of mold employed for the individual plate, and on the location within the plate.

Figure 14 shows the elongation and reduction of area at various locations in the plates of the sand cast, low sulfur heats (Heats A, B and C). All plates show optimum properties at the location farthest from the riser, the best being obtained in the plates which were chilled. Lowest properties were obtained about 2-4 in. from the end of the plate, with improvement being obtained at a distance of 5 in. from the plate end (under the riser).

Figure 15 illustrates the same mechanical properties for the three castings of low sulfur content poured in ethyl-silicate molds. Except for the anomalous behavior of elongation values of Heat *F*, the elongation and reduction of area properties for the ethyl-silicate mold are of the same order of magnitude or slightly lower than the comparable properties for the casting poured in silica sand with no chill.

Microporosity Effect

Comparing the mechanical property data of Fig. 14 with the microradiographs of Fig. 11, it may be seen that the lowest properties are obtained generally in the areas of greatest microporosity. In the case of the ethyl-silicate mold (Heat *D*, Fig. 15), minimum properties are also obtained in the locations where microporosity is greatest. However, if microporosity were the only variable acting, it would be expected that the properties of the casting poured in ethyl-silicate would be somewhat higher than the properties of the casting poured in silica sand (because mircroporosity is less).

That the properties of the casting in the ethyl-silicate mold are not higher than those in the sand mold is taken as an indication that other factors are important in determining properties, including microsegregation and inclusion count and distribution.

Elongation and reduction of area properties of the high sulfur casting poured in silica sand with no chill are listed in Table 3. These properties are generally lower than those of the comparable casting poured with low sulfur metal (Heat *C*), indicating the deleterious effect of the higher sulfur and the consequent unfavorable type inclusions.

Impact strengths of all heats poured are also listed in Table 3. The values are low for the tensile

TABLE 3 — MECHANICAL PROPERTIES OF PLATE CASTINGS

Yield Strength (psi, 0.2% offset)

Bar Position	Heat A	B	C	D	E	F	G
1	175,500	177,500	180,000	177,500	172,500	172,500	176,250
2	177,500	176,500	175,500	177,500	173,750	165,000	176,250
3	176,250	178,500	177,000	177,500	173,750	182,500	177,500
4	177,500	176,000	175,000	177,500	173,750	182,500	175,000
5	180,000	175,000	—	177,500	172,500	182,500	175,000

Ultimate Tensile Strength (psi)

Bar Position	Heat A	B	C	D	E	F	G
1	209,250	210,500	211,750	211,000	206,250	207,000	209,000
2	210,000	219,750	208,000	210,500	200,250	207,500	208,750
3	209,500	211,750	209,250	211,000	207,500	207,500	207,500
4	211,750	209,250	207,750	208,750	205,000	206,000	207,500
5	212,000	208,000	207,500	209,250	203,750	207,000	204,500

Elongation (% in 2 in.)

Bar Position	Heat A	B	C	D	E	F	G
1	12	13	10	7.5	9	11	8
2	8	9	6	7	1.5	11	4.5
3	5.5	7	6	5	5	10	4
4	5	8	5	5.5	5	10	6
5	7	10	8	10	8	10	8

Reduction in Area (%)

Bar Position	Heat A	B	C	D	E	F	G
1	39.3	38.5	26.4	17.9	25.0	—	18.6
2	22.4	22.6	8.2	17.6	3.6	—	7.4
3	10.2	18.9	11.9	7.1	6.4	—	5.0
4	7.4	18.9	10.6	7.8	10.2	—	10.0
5	19.5	24.2	20.2	25.4	22.0	—	21.4

Impact Strength at −20 F (ft lb)

Bar Position	Heat A	B	C	D	E	F	G
1	14.9	14.5	11.8	10.0	14.2	11.2	8.9
2	13.6	12.7	6.2	9.2	14.2	7.5	9.5
3	8.6	10.6	8.9	10.9	12.4	12.4	7.3
4	5.4	10.3	10.0	9.7	10.6	12.7	10.9
5	10.6	8.9	12.4	13.0	13.6	12.4	7.8

strengths of the metals used in this investigation, and show no particular correlation with location in the plate. This lack of correlation is felt to be partly due to the fact that duplicate tests were not made; only one test was made for each location in the plate. However, it is also felt that the tempering temperature employed may have been too close to the 500 F embrittlement range.

Ultra-High Solidification Rate Studies

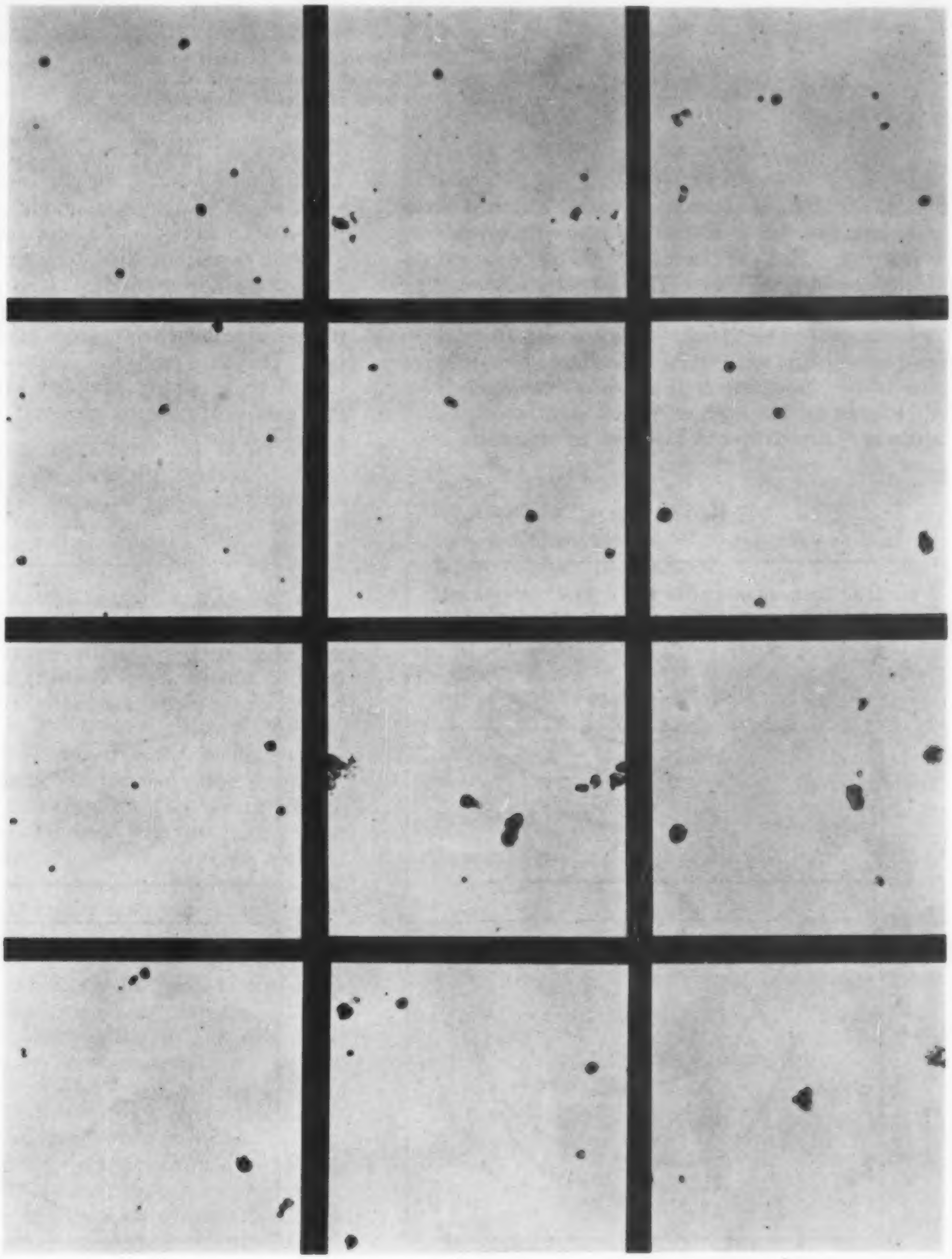
To further examine the effect of cooling rate on structure and properties, the modified 4330 alloy used in this investigation was solidified under extremely fast cooling rates obtained by melting and resolidification of a large plate section by arc welding. Cooling rates obtained were calculated to be approximately 700 F/min, as compared with maximum cooling rates in the chill plates of the order of about 300 F/min. Figure 16 illustrates a typical structure obtained in the weld deposits. An extremely fine dendritic structure results; note the photomicrograph is magnified to 500×.

a

b

c

d



1 2 3

Fig. 12 — Appearance of inclusions in test plates. Unetched, 300 ×. Distance from plate end — *row 1*, 1 in.; *row 2*, 3 in.; *row 3*, 5 in. Horizontally — *row a*, zircon sand mold, end chilled; *row b*, silica sand mold, end chilled; *row c*, silica sand mold, no chill; *row d*, ethyl-silicate mold, no chill.

Fig. 13 — Appearance of inclusions in plate of high sulfur (0.017 per cent) metal cast in silica sand mold, without chill. Left to right — 1 in., 3 in. and 4 in. from plate end. Unetched. 300 ×.

Cooling in the weld deposit after solidification is so rapid that martensite and fine carbides are formed.[34] In fact, excellent mechanical properties can be obtained in a structure of this type by employing only tempering treatment after the casting (no austenitizing treatment). Figure 17 illustrates a tempering curve for a series of welds. Hardness (Rc) was measured at tempering temperatures varying from room temperature up to 1000 F; these hardnesses indicate that tensile strengths result which are the same order of magnitude as are obtained in homogenized, quenched and tempered castings.

Also, bend tests performed on weld deposits indicated a minimum of 10 per cent elongation in the weld, which compares favorably with the mechanical properties obtained in the heat treated cast plates.

While homogenization treatments of weld deposits have not yet been studied, it is apparent that these weld deposits are an excellent tool for studying the possible beneficial effect of intense homogenization. The extremely fine structure obtained should lend itself to almost complete elimination of microsegregation of alloying elements at ordinary temperatures in a reasonable time.

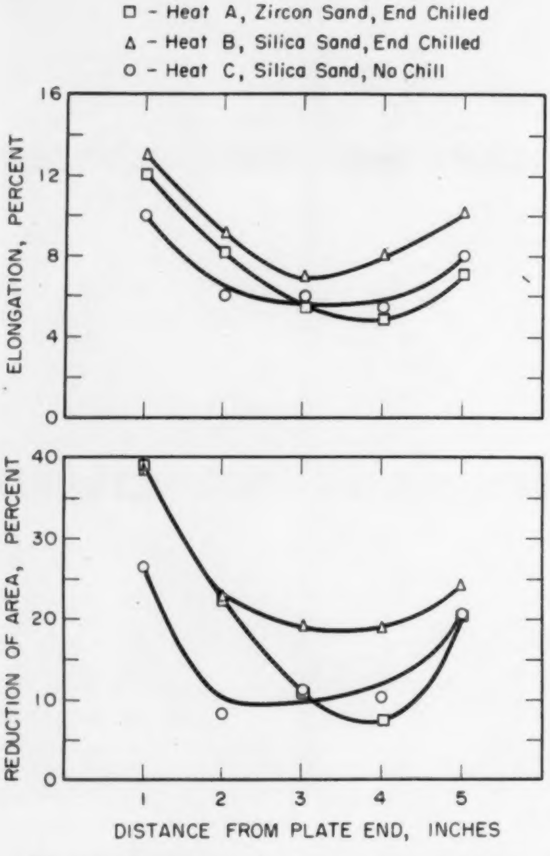


Fig. 14 — Elongation and reduction of area in zircon and silica sand plates.

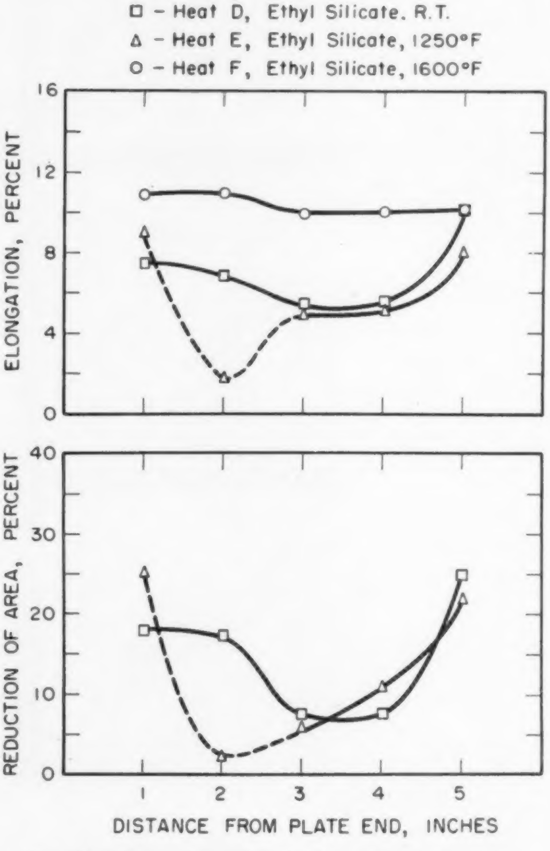


Fig. 15 — Elongation and reduction of area in ethly-silicate plates.

SUMMARY AND CONCLUSIONS

Plate castings of modified 4330 alloy were poured in a variety of different molding materials to obtain different solidification conditions. Molds employed were 1) zircon sand mold with a metal chill at the end of the plate, 2) dry sand mold chilled similarly, 3) dry sand mold without chill, 4) ethyl-silicate bonded mullite mold without chill, room temperature, 5) ethyl-silicate bonded mullite mold without chill, preheated to 1250 F and 6) ethyl-silicate bonded mullite mold preheated to 1600 F.

A wide range of solidification conditions were obtained in the above molds. Cooling rates as high as 300 F/min, and thermal gradients as high as 350 F/in. were obtained 1 in. from the plate end (in the end chilled, zircon sand mold). Cooling rates and thermal gradients decreased along the length of the plate. In the most insulating mold (ethyl-silicate bonded mullite, heated to 1600 F), cooling rate was only 20 F/min and thermal gradients were 70 F/in. at 1 in. from the plate end. The cooling rate and thermal gradients measured were those existing at a given location in the plate near the end of solidification at that location.

Macrostructures of the plates were not appreciably affected by varying thermal conditions. All castings showed predominantly columnar (original austenite) grains. Microstructure was, however, affected markedly; fast cooling rates produced an extremely fine structure within the austenite dendrites. Slower cooling produced a substantially coarser structure. The "fineness" of the structure (spacing between dendrite arms) is apparently dependent only on cooling rate.

Microsegregation in the as-cast structure was not eliminated by the heat treatment employed. Even the finest chilled structures showed some segregation after heat treatment although these should be most amenable to elimination of such concentration gradients.

All castings were examined radiographically and found to be free of macroscopic centerline shrinkage. Sections 1/8-in. thick cut from the plates were also radiographically sound. However, microradiography of sections 0.020 in. thick disclosed voids at or near the centerline in all plates examined. The amount and distribution of these voids were dependent on the mold material employed and it was concluded that the voids were microshrinkage. The unchilled plate cast in silica sand exhibited the most severe porosity (between 2.5 and 4.5 in. from the plate end).

Inclusion size and distribution in the cast plates were also dependent on mold material and on location within the plate. Fast cooling rates resulted in fine inclusions, evenly distributed; slower cooling rates produced coarser, more agglomerated inclusions.

Mechanical properties were determined at various locations in the plate castings; properties determined were ultimate tensile strength, yield strength, elongation, reduction of area and impact strength. The castings were heat treated to obtain strength levels of 210,000 psi ultimate and 180,000 psi yield strengths; all bars tested were of these strengths ±2000-3000 psi.

Elongation and reduction of areas were dependent on the molding material employed and on the location in the casting. It was found that:

a) Optimum properties were observed in the end chilled plates, near the chill.
b) Properties of the end chilled plates decreased to a minimum at between about 3 and 4 in. from the chill and then increased again at 5 in. from the chill (under the riser).
c) Properties of the unchilled plates varied along the length of the plate in similar fashion to the above, but were generally lower.

The lowest elongation and reduction of area properties in each plate were found in the region where microporosity was observed to be greatest, and this microporosity was concluded to be a major factor in contributing to the low properties. It is apparent,

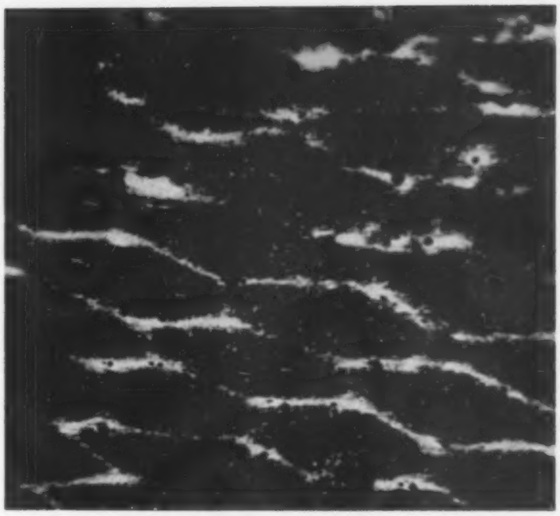


Fig. 16 — Microstructure of a solidified weld deposit of 4330 alloy (modified). Etched. 500 ×.

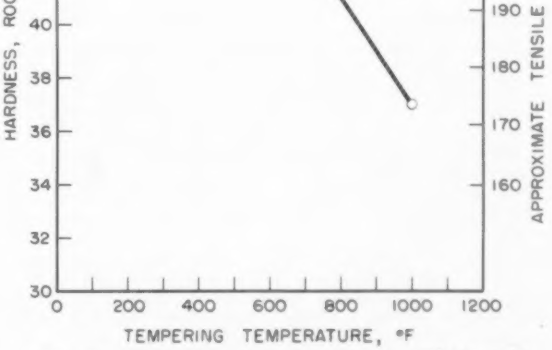


Fig. 17 — Tempering curve for 4330 (modified) weld bead.

however, that other factors, particularly microsegregation and inclusion distribution, may be important in determining properties in the plates. For example, elongation and reduction of area at the location only 1 in. from the plate end are appreciably higher in the chilled plates than in the unchilled plates.

At this location, no microporosity was observed in any of the plates, and the improvement in the chilled plates is apparently due to reduced microsegregation or to improved distribution of inclusions resulting from the fast cooling.

Conclusions above are based on study of high purity material (less than 0.01 per cent sulfur and phosphorus). One plate cast with higher sulfur (0.017 per cent S) exhibited substantially lower elongation and reduction of area properties. Inclusions were larger than with the low sulfur metal and were also of unfavorable elongated (Type 2) distribution.

Impact properties of bars taken from the cast plates showed no correlation with location in the plate or with solidification variables. One reason for this is thought to be the few tests performed.

The effect of ultra-fast cooling on the structure of cast low alloy steel was examined briefly, by arc melting on a solid, cold plate. A dendritic structure many times finer than that produced in sand castings resulted. At high strength levels the structure so produced possessed good ductility after only a tempering heat treatment. Homogenization should completely eliminate microsegregation in the fine dendritic structure without use of excessively high temperature.

Thus, material cast by arc welding should prove useful in determining what beneficial effects might result from complete elimination of microsegregation in cast low alloy steels.

ACKNOWLEDGMENTS

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CORE BOX RIGGING FOR HIGH PRODUCTION

By W. H. Miller

ABSTRACT

Most foundries have their own formula for determining the size of core boxes and driers. This formula is dictated by available facilities such as core blowers, core ovens, core racks, etc. With this in mind this paper includes a discussion of those items of rigging that have proved successful at the author's company in helping to develop a relatively high production standard with minimum core box maintenance required. The majority of the items to be discussed may be unique at this foundry, but can be used by many foundries regardless of their facilities.

INTRODUCTION

The definition of high production would vary depending upon individual experience. The writer feels that high production exists when one man can operate an interchangeable blow machine at the rate of at least 160 blows/hr while making an average size core. Of course much higher production can be obtained from a special one job machine.

Because the term "core box rigging" can be construed to include the entire design and manufacture of a set of core boxes, the writer feels it necessary to pre-determine the limits of this discussion.

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Only oil sand, blow type, steel faced, magnesium core boxes will be considered, although some of the items to follow are applicable in other situations. Upper half core box will mean the top core box or the core box half which contains the blow holes. The lower half core box will be the bottom.

The type of lower half core box to be discussed is not unusual, but the upper half is of special design. Figure 1 is a cut away sketch of an upper half core box. Note that the box is made in two pieces—1) the main body, which contains the core cavity, and 2) the top magnesium plate, which is used to hold the blow tubes. The top plate also contains the upper half core box mounting holes.

PLAN FACILITIES

Probably the most important requirement in a high production core room is interchangeability, especially where different kinds of cores are required in large volumes. This type of core room has to be well planned particularly when obtaining blow and draw machines. The machines need not be of the same make, but they should have the same dimensional characteristics such as daylight and core box capacity sizes, minimum and maximum. The machines

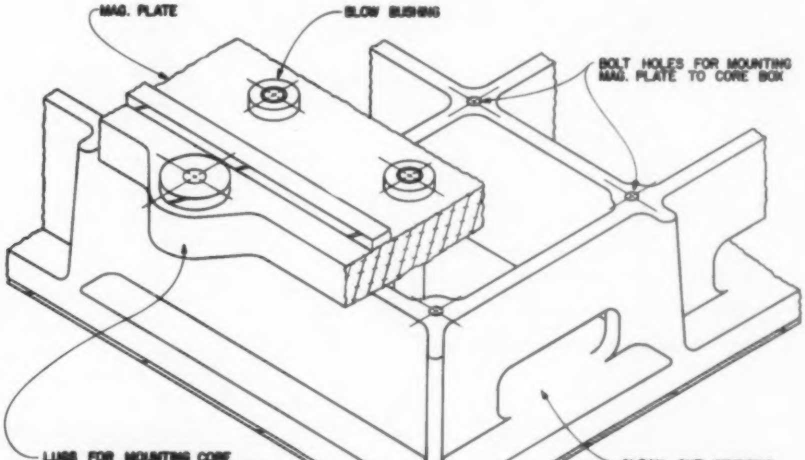

Fig. 1 — Cut away section of upper half core box.

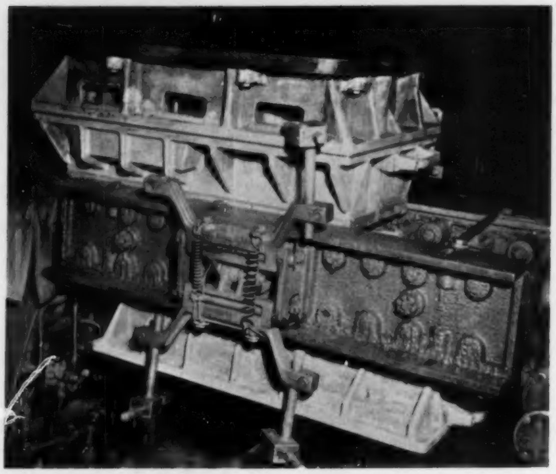

Fig. 2 — Typical set of core boxes being put on a machine setup.

should also have identical core box guiding, locating and holding systems.

With a core room thus equipped, one set of core boxes can be removed from a machine setup, and another set, used to make an entirely different core, can be installed during a half-hour lunch period. Figure 2 shows a typical set of core boxes being put on a machine setup. The machine and core boxes have been standardized to a point that the only installation work required is to fasten the upper half core box blow plate assembly to the sand reservoir and adjust the core box end stops on the blow and draw machines. The core boxes are made with guide rails and center locator standard so as to fit many machines.

The reservoir is a standard size, 10.00 by 26.00, and is designed to be used with a great number of core boxes. Of course the draw mechanism must be adjusted in most cases because of the variation of core heights. In many cases the physical dimensions of core boxes are identical and no machine adjustments are necessary. With the above setup over 600 core boxes, at the author's company, can be used on the same machines with no major adjustments required.

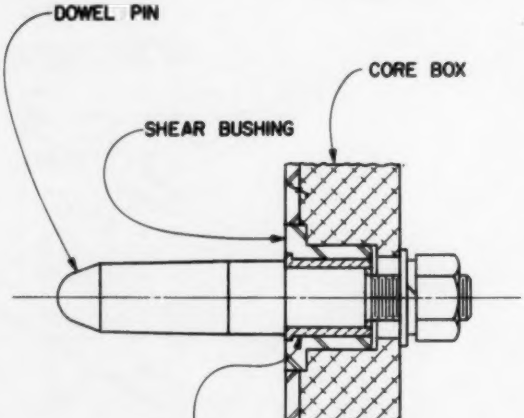

Fig. 3 — Shear bushing assembly.

CORE BOX CLEANING WINDOWS

It is extremely important to furnish high production core room supervision core boxes that can be used hour after hour with a minimum of trouble in making quality cores. A properly screened core box with a liberal number of well placed blow holes will generally suffice. However, such a core box must include certain other features to sustain a high rate of production. For example, sand fines will escape through vent screens while a core is being blown. Some of these fines will lodge in the screen passages, and eventually accumulate to such an extent that the passages become plugged and not usable.

To overcome this undesirable condition, windows have been cast in the sides of the upper half core boxes (Fig. 1). An air hose nozzle can be inserted through the window and used to blow the screen passages clean. Core boxes without cast windows must be removed from the machine for cleaning after 4 hr of use, while the boxes with windows can be used steadily for 16 hr.

CORE BOX SHEAR BUSHING

The core box pin can create a problem. If a machine functions out of cycle and starts to close the lower half core box with the upper half core box before proper centering has taken place, the core box pin ear will be broken. The prevent core box damage in such an instance a shear bushing assembly has been developed and installed in all core boxes. Figure 3 shows this assembly. A steel flanged type bushing is installed in the core box first. Next a brass bushing is installed. You will note that this bushing has a small flange and shoulder. Finally, the core box pin is installed.

In the case of a machine operating out of cycle, as noted above, the only damage, in most cases, is to the brass bushing. This brass bushing can be replaced in a short time while the core box is still on the machine. This greatly reduces machine downtime and core box repair costs.

BLOW TUBES

Many types of blow tubes have been used in core rooms throughout the foundry industry, and many opinions have been expressed for and against these various types. In the writer's opinion, the most trouble free and long-lasting type is shown in Fig. 4. This blow tube is an assembly consisting of three parts, 1) the blow bushing, 2) blow bushing liner and 3) blow bushing insert. The blow bushing is made of cold rolled steel and is turned with a 0.25 in. thick flange. This flange is used as a spacer between the upper half core box and blow plate, and also as a seal at the blow plate. The inside diameter of the blow bushing is made to accept the liner, slip fit and the insert, press fit.

A plain piece of standard stainless steel tubing, ground on the outside diameter, is used for the blow bushing liner. The liner is held in place by

melting a small amount of solder between the liner and the blow bushing. Stainless steel is used because of its durability. The blow bushing insert is pressed into the bottom of the blow bushing. You will note the back angle of the inside of the blow bushing insert (Fig. 4). This back angle is used to separate the sand within the blow tube from the blown core during the draw operation.

As is the case with all surfaces in a core box, the blow tube is subject to wear and must be maintained. The liner should be replaced before it gets worn through, and the blow bushing insert should be replaced at the first sign of a sand stool on the drawn core.

MAINTAINING CORE BOXES

A core box rigged for use in high production must be durable. Continuous blowing of sand under pressure can cut a core box in a short time. The areas most susceptible to this cutting action are generally directly below the blow hole, vertical side walls adjacent to the blow hole tip and restricted passages within the closed core box. With this in mind, finite attention should be given to these areas when preparing a core box for production use.

The writer does not know of a "miracle material" that will withstand sand abrasion and still meet all of the other core box material requirements such as strength, machineability, satisfactory initial cost, etc. Consequently, steps should be taken to insert steel or copper change pieces in a new core box. With this type of core box construction, close dimensional control can be maintained by changing inserts as often as necessary. The insert principle increases the efficiency of a core box since the amount of time necessary to keep the core box out of production for repairs is greatly reduced.

Figure 5 shows a new type wear pad that is installed whenever possible directly below the blow hole in the lower half core box. A hardened steel washer is inserted in the core box and a large flat head screw is threaded in place. This simple assembly forms a backdraft hole. When the first core is blown the hole is filled with sand, and since it is packed in a backdraft area the sand will not draw out when the core is removed. The sand that remains in the core box becomes an effective wear pad as subsequent cores are made.

Of course, the washer and screw will wear in time and must be replaced. This wear pad assembly should not be used indiscriminately since it will mark the core slightly.

VENTING

Core box venting is generally accomplished by installing vent screens. The size and mesh of the screens, as well as their location, is controversial and therefore will not be discussed. Much more can be accomplished by pointing out other methods of venting that can be used in core boxes along with vent screens. Figure 6 shows a good example of the use of sheet screening. In this particular example the core is too small to install the smallest standard vent screen and still have room for the required vent pin. The sheet screening is backed by a steel plate in which small holes spaced around the periphery have been drilled.

Care must be exercised when choosing the hole size since the sheet screen will buckle into too large a hole while in use. This type of venting is extremely effective and can be used extensively.

Another method of obtaining core box venting is by use of clearance around core box insert pieces. For example, when inserting a barrel in a cylinder block water jacket core box, the insert can be made about

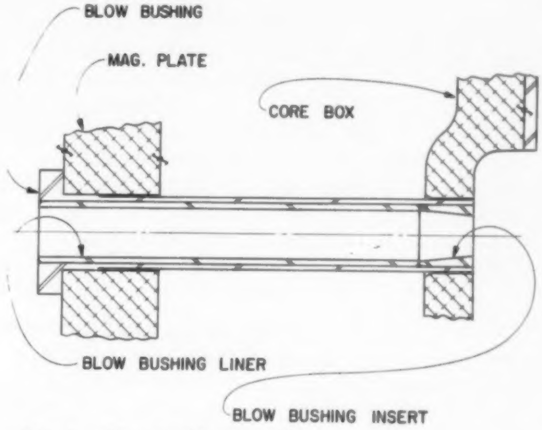

Fig. 4 — Blow bushing assembly.

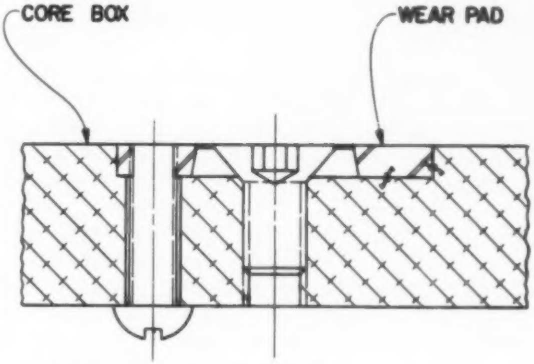

Fig. 5 — Wear pad installation.

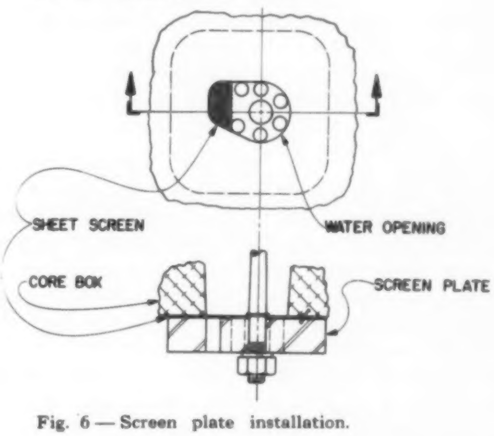

Fig. 6 — Screen plate installation.

0.015 in. smaller in diameter than the core box. By drilling a series of small holes in the core box beneath the insert piece, a type of vent is completed.

If a small hole appears in a core on a surface that is adjacent to an internal parting, the probable cause is trapped air. By cutting a 0.25 in. wide x 0.007 in. deep channel into the parting and terminating this channel at a screen, also installed in the parting, this problem will generally be solved.

All of the items included in this discussion are now being used at the author's company, and possibly have been put into use in other foundries. In each instance a definite cost savings or quality improvement has been established. The foundry industry has made rapid strides with the advent of high production core blowing and certainly within a few years the methods of rigging as described above will probably be obsolete.

FOUNDRY DESIGNING FOR STEEL CASTINGS

By Alfred B. Steck

ABSTRACT

The foundryman is forever blaming castings defects on design. He is at best a third guesser in eliminating defects after the casting has been made. More effort should be placed on foundry designing for steel casting. With this in mind the latest techniques in controlling hot tear defects are explained.

INTRODUCTION

Why is it that in a production run of castings there are found good castings and bad ones? If design is blamed for bad ones, what is blamed for the good ones? Certainly, if there are good ones among many bad ones, foundry techniques are not consistently good and, therefore, design should not be blamed.

It remains to determine what variables are present in foundry processes; to design processes with a minimum amount of variables; and to keep these variables under control.

The theme of this paper is aimed at developing a systematic approach towards foundry designing for steel casting. The nature of the defect should be determined, the cause found and removed and the process redesigned so that the defect will not reoccur. The systematic approach can not be over emphasized because too often the foundryman pushes the panic button and changes all variables at once.

Perhaps he gets out of trouble and maybe not, but the fact remains that if he does get out of trouble, he does not know why. Actually he is still in trouble because when the defect reappears, he does not know which variables to change to correct the defects.

A casting and its manufacture must be looked upon as being made up of materials and the reaction of these materials to high temperatures. With this in mind let us look at the so-called design defects encountered in the casting of steel, and how the modern foundryman designs his process to eliminate these defects. The design defects of main concern are those called hot tears.

HOT TEARS

For all practical purposes it may be said that hot tears occur in the vicinity of the solidus of metal systems. This means that if the steel casting is not allowed to contract freely during the liquid-film stage of solidification, a hot tear will occur. The first step is to identify the defect. The hot tear is recognized as a jagged crack which is discolored due to oxidation of the crack surface. On close examination the surface of the crack appears to have parted when liquid metal was present.

The next step is to determine what is preventing the casting from freely contracting during the liquid-film stage by looking at that material which is at right angles to the plane of the hot tear. If the material is core or molding sand, then the strength of the sand mixture must be weak when the steel goes through its liquid-film stage.

Chemical Composition Effect

It must be remembered that as the chemical composition of the steel changes, the liquid-film stage changes. A sand mixture designed specifically to prevent hot tearing in an 0.60 per cent carbon steel may not be satisfactory for an 0.20 per cent carbon steel. The 0.60 carbon steel will tear at about 2550 F whereas the 0.20 carbon steel will tear at about 2675 F.

Also the liquid-film stage of a basic steel is different from that of an acid steel so that some casting configurations will tear more readily with acid steels than with basic steels, and vice versa. This change in film stage can be related to the greater amounts of sulfur, phosphorus and oxygen present in the acid steel. These elements lower the solidus temperature and this changes the liquid-film stage.

It should be remembered also that hot strength of sand mixtures is a time dependent reaction. That is to say, the hot strength of dry sand mixtures heated rapidly will be equal to the baked strength as tested in the laboratory. This is assuming that the laboratory specimen is rammed to the same density as the sand in the mold or core. This means that on thin sections of castings subjected to hot tears, sand mixtures must be designed to have low baked strength rather than low hot strength.

Heavy Section Castings

On heavy sections prone to hot tearing, sand mixtures must be designed for low hot strength. For example, in designing a core for a ⅜-in. wall casting which is prone to hot tearing, one should design the sand mixture so that it will have to have extremely low baked strength—of about 200 psi compression to prevent hot tearing. Large cores surrounded by thin metal sections of necessity will be too weak to handle.

It is well to coat these cores with a thin layer of wash to give the cores more physical handling

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strength. Another scheme which helps is that of making the drag portion of the core stronger than the cope portion, and in this way the entire core is easier to handle.

If it is found that hot tearing still occurs when the core and mold material is as weak as practical at hot tearing temperatures, some means should be found for changing the time of hot tearing. Thus, hot tearing will be a function of the hot strength of sands rather than a function of the baked strength. It is much simpler to alter hot strength properties than baked properties because cores must have a minimum baked strength for handling, whereas hot strength requires no minimum or maximum for handling.

High Temperature Pouring

One way of changing the time of hot tearing on a thin wall casting is to pour the casting at a higher temperature. If the core has been designed for low hot strength at the tearing temperatures, no hot tears should result. This is because the high pouring temperature will have burned out the bond which created the baked strength. If the core had been underbaked, the heat of the molten metal will continue to bake the core, the baked strength will increase rather than decrease and more hot tears will result.

Many foundrymen believe that if a sand mixture has good shakeout or low retained strength properties, few hot tears will result. This is false thinking as exemplified by the cold setting binders. Even though good shakeout properties result, hot tears in thin sections may occur, because the baked strength of the cores made of cold setting binders can be high. Also there is a tendency to underbake these cold setting binders with the result that strength increases from the heat of the poured metal.

Thin Section Addition

Another way of changing the time of hot tearing so that baked strength is not a factor is that of adding false padding to the thin section making it appear like a thicker section. This involves casting extra metal parallel and close to the section that is tearing. The sand between the casting and the false padding will be heated to high temperatures, and thus make the thin section appear like a thick section. Care should be used to see that the section which is made thicker does not require additional feeding.

If the transition from one section to another on the casting is drastic and hot tearing occurs, it is well to strengthen the section junction with ribbing which should be removed prior to shipment.

CRACKING

Another type of defect commonly called a hot tear but really is not, is cracking which emanates from shrinkage cavities. The cracking or tearing normally does not break through the casting surface, but can be picked up readily by magnetic particle inspection. The tearing is a result of the stresses occurring during solidification. The obvious solution here is to feed the casting properly or chill the area to strengthen the metal against tearing when the solidification stresses are high.

The so-called bore cracking on cast valves is a result of solidification stresses. In an unfed square section, tears will emanate at right angles to all four sides. As the section changes from a square to a rectangle, those tears perpendicular to the long sides gradually disappear.

CONCLUSION

If hot tears come and go in particular castings, the mold and core materials causing the hindered contraction should be designed to be weak when the molten steel passes through its liquid-film stage. Every effort should be made to control the process variables causing the come-and-go type of hot tearing before blame is placed on casting design.

FLUORESCENT PENETRANT METHOD FOR CASTING INSPECTION

proper interpretation and inspection

By Arthur Lindgren

ABSTRACT

The use of a fluorescent penetrant in casting inspection is considered, as a method of locating defects. The principals of this type of inspection are given, as well as examples of its use. The need for close cooperation between the foundry and the casting buyer is also emphasized.

INTRODUCTION

Two wrongs do not make a right, but under certain circumstances two rights actually make a wrong. Recently, it happened, and since it involves castings it was thought you would be interested in some of the details.

Standing behind an inspector in a production malleable foundry using fluorescent penetrant, it was observed that one out of five castings were being set aside as being rejectable. The specifications agreed upon by both buyer and seller called for 100 per cent fluorescent penetrant inspection with no indications. By indications we mean a small accumulation of powder particles which form on the surface of the casting directly over a crack-like imperfection. A close examination showed that the majority of these indications were little more than surface irregularities. Only about one in 20 of the castings being set aside had a depth exceeding 0.002 in. In effect, if the specifications had been followed to the letter, quite a few castings would have been slated for remelt.

As a practical matter, many of these "rejected" castings were actually salvaged by wire brush or grinding, and after reinspection were shipped to the customer. This meant additional manufacturing cost. The point is, the foundry had done its part. Since they had accepted this specification along with the order, they did follow through despite the fact that it would eventually cost them and the customer additional dollars.

How about the casting buyer? Was he right? He was. This was not a brand new part to him, it had formerly been a forging. He knew the stresses involved. In overall design, it was a critical part. However, he knew he could get the strength he needed in a casting and that the cost to him would be less, but it had to be crack-free. What better way out for him than to insist upon a 100 per cent inspection with fluorescent penetrant, allowing no indications.

Here is a situation where two groups are both in the right, and yet both are destined to lose in the long run. Even though the buyer saved money by going to a casting, actually he could have saved more had he said defect rather than indication in his specification. The foundryman knew he could produce this part for less money and pass the savings on, but under these conditions he is unable to do so. Who is to determine what is a defect and what is not? This is the problem. How can it be solved?

WHAT FLUORESCENT PENETRANT IS

Suppose we start by first seeing just what the fluorescent penetrant used is, and second determining how it is used. At one time or another, you have all made use of a small horseshoe magnet for picking up nails, paper clips or metallic dust. If you dip the two poles of the magnet down into iron filings, you know that the particles will readily adhere to it. The magnetic (flux) field travels through the magnet and passes from the North to the South Pole. These little flux lines would a thousand times rather travel through steel than they would through air, and once started they must continue to flow.

As they reach the North Pole, they jump out of the magnet and return to the South Pole by the easiest possible route. Remember, they would a thousand times rather travel through steel than they would through air. The nail you see hanging to the magnet in Fig. 1 furnishes the easiest possible route of return.

If the poles of the magnet are bent around until they almost touch the magnetic flux line jumps from one pole to the other by the easiest possible route. Going a step further the two poles can be fused together. Now the magnetic lines are free to travel completely within the magnet, and there is no external evidence that they even exist. If we were to define a magnetic pole on a part, it would be "that area on the part where lines of force are either entering or leaving the part." Figure 1 also shows that the magnet now no longer has poles (lower left view).

A. LINDGREN is Field Engr., Magnaflux Corp., Chicago.

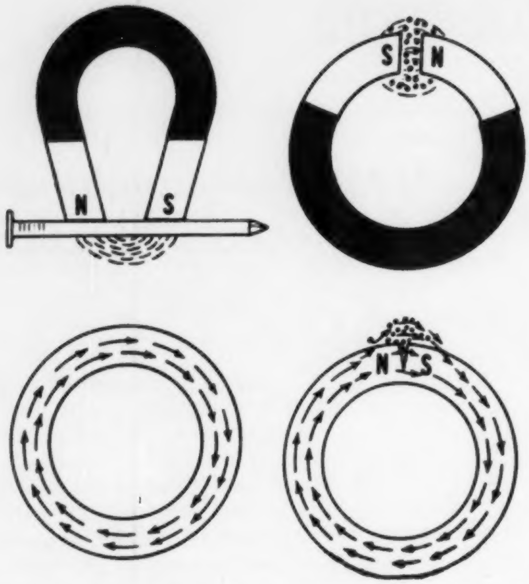


Fig. 1 — Upper left — The nail offers the flux lines the easiest possible return line between the North and South Poles of the magnet. Upper right — Bending the magnet poles so they almost touch the flux lines jump from one pole to the other by the easiest route available. Lower left — Fusing the two poles together allows the magnetic lines to travel completely within the magnet. Lower right — Cracking the magnet so it is not completely severed forces some magnet lines to jump the gap, as North and South Poles have again been created. Some flux lines successfully continue through the unsevered part of the magnet.

One final step can be taken and the magnet can be broken again. Since it is not completely severed (Fig. 1, lower right), in effect we have a crack in the magnet. Remember, the lines of force much prefer traveling through iron or steel, so as they approach the crack they attempt to by-pass it. Some of the lines successfully pass through the unsevered portion of the magnet, while others are forced out of the part and jump across causing a small leakage magnetic field.

This occurs as long as the lines of force are crossing the crack at a right, or nearly a right, angle. If fine metallic particles are applied to the vicinity of the crack, they will adhere rigidly to it and build a bridge for the flux lines just as the nail did. This bridge of magnetic particles is called an indication, but we should add an indication of what—in this case, it is an indication of a crack.

Basically, this is magnetic particle inspection. To make the method more practical on small size castings, the magnetic particles are manufactured very small and each is coated with a fluorescent dye. They are then suspended in either water or light oil distillate and flowed onto the part at the time it is being magnetized. Should the part be able to hold a magnetic field for a long while, like the magnet Fig. 1, we may magnetize first and apply the particles afterward. A pearlitic malleable casting, for example, will hold a residual field for a long time. On the other hand, a regular malleable casting loses a good portion of its magnetism almost immediately, and, therefore, the particles must be applied at the time the part is being magnetized.

MAGNETIC FIELD

Creating this magnetic field within a part is simple. The current can either be passed through the part, through a central conductor within the part, or it can be passed around it using a coil. The part cannot be magnetized in both directions at the same time. This brings us to an important point. Some castings must be given two inspections in order to find all possible defects. The important rule to remember is to pass the current in the same direction as the defect you wish to find. For example, to find a seam in a bolt, you pass the current from one end to the other. If we were looking for transverse defects up underneath the head of the bolt, we would place it in a coil, thus passing the current in the same direction as the crack.

This is the theory of fluorescent penetrant inspection. One of the most typical castings inspected this past year has been the automotive yoke. Suppose there are three places where cracks might appear as shown in Fig. 2. The defects at *A* and *C* are located easily by sending current directly through the part. If we were looking for the defect at *B*, the yoke would be processed in the coil. In each case the current is passing in the same direction as the defect.

The foundryman knows where defects are likely to occur. The user knows where the critical areas are located. Having all this information available, the trained inspector can set up the proper test procedure. A crack at *C* is unlikely and would not be dangerous if it did occur. However, even a small check at *B* could lead to failure under repeated stress, so a coil shot on this yoke is a must. This coil shot will also show any crack of any consequence which breaks over the edge at *A*. By using only a coil shot we will also avoid showing small surface blemishes at *A* which are normally of no consequence, and which would take up valuable inspection time on the evaluation.

For another example, consider a chain drive

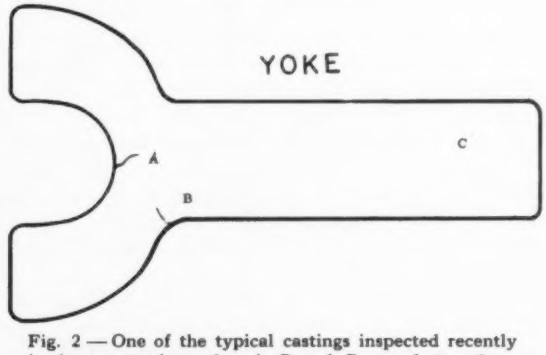


Fig. 2 — One of the typical castings inspected recently is the automotive yoke. *A*, *B* and *C* are places where defects are likely to occur. A defect at *B* is dangerous, but not too likely to occur in the casting process. Defect C is not dangerous, and its occurrence also would be rare. Defect *A* is dangerous if it breaks over the edge as shown, and can occur in the casting process. This defect should be watched for closely.

sprocket casting, as shown in Fig. 3. Any defect in the area of the teeth could be important, particularly if the part is to be heat treated later. Hot checking or shrink around the hub is also important, but only if it is gross in nature. Radial checking is also possible. We, therefore, conclude that a central conductor shot (pass current through a copper bar which has been passed through the center of the hub) will find any possible radial cracks or defects in the teeth area and would also show gross hot checking in the hub area. A pilot run inspection only should suffice. Maintaining 100% inspection here would be wasted dollars.

One more example is a trailer hitch as shown in Fig. 4. If this were made as a fabrication, we may find defects occurring at points *A*, *B* and *C*, and perhaps a few more places. At point *B*, the stress is low and the occurrence of a casting defect unlikely. Should one occur at point *A*, it could be highly critical. At point *C*, if the radius were not made smooth, a hot check could occur. From a use standpoint, this area is always in compression, and by proper contouring of the part the possibility of a crack going over the edge is almost impossible. The answer is a coil shot during the pilot run to watch areas *A* and *C* closely. Once the first run has been successfully made, a percentage inspection should give excellent assurance of quality.

CASTING EXAMPLES

The complicated part shown in Fig. 5 is a good example why many firms have gone to the foundry to find the most economical approach to their requirements. With a casting you can get not only the high strength required for a part, but can have it at much less original cost. Fabricating this part would be difficult. To obtain the most desirable shape using a minimum of material, eliminating all unnecessary machining time, the answer adds up to a casting. Toward the center of the part there is a small surface imperfection.

Normally, this is of little consequence, but at pilot run it suggests slight modification. With one slight change in the contour, however, even this imperfection was eliminated during the pilot run. Future trouble was thereby eliminated. One coil shot during pilot run found this, and would have found anything else of consequence.

Figure 6 shows a similar casting having a defect more major in nature. Here again, the difficulty was caught at once by the foundry's thorough quality control program. A simple coil shot during pilot run was the answer. While this crack might not be detrimental in service, as it is only an aligning bracket, it is the aim of the foundry to eliminate any possibility right at the beginning. In reality, it is now an engineered product.

Figures 7 and 8 represent a similar condition in another casting. This part replaces a fabrication at a considerable savings to the casting buyer. A complex shape was resolved into an attractive product. Nothing was given up in either strength or performance. Even a minor flaw, as seen in Fig. 7, found by a coil shot, was eliminated by a small change in contour. In Fig. 8, another check was eliminated simply by adding the smooth radius you see at approximately the center of the casting.

With all the advantages to be gained, not the least of which is economic, by converting some parts to castings, there should be some way for the buyer and seller to get together on common ground. It is to their mutual advantage to produce the part at a minimum

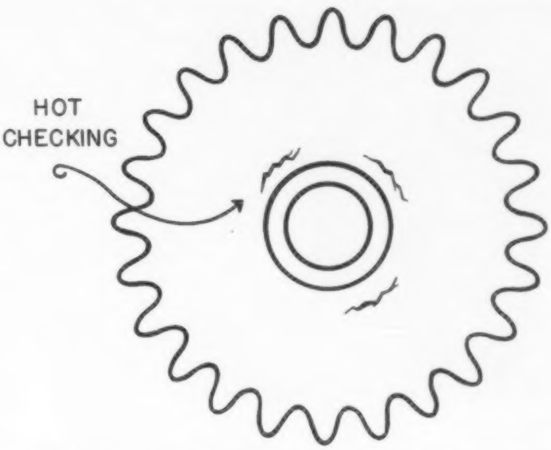


Fig. 3 — A chain drive sprocket casting showing possible hot checking around the hub. If good control is not maintained, discontinuities such as these are likely to occur.

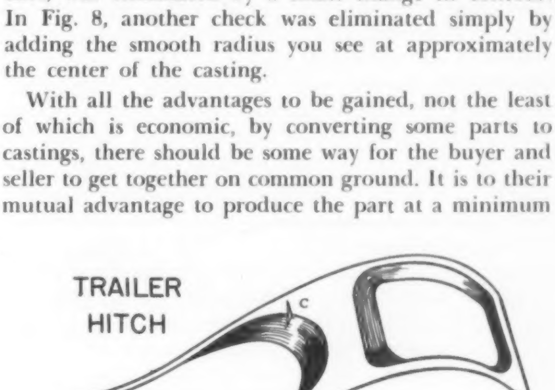


Fig. 4— Defects can be seen in this trailer hitch as points *A*, *B* and *C*. At point *B* the stress is low and the occurrence of a casting defect unlikely. A defect at point *A*, if it should occur, could be highly critical. If the radius at point *C* were not smooth a hot check could occur.

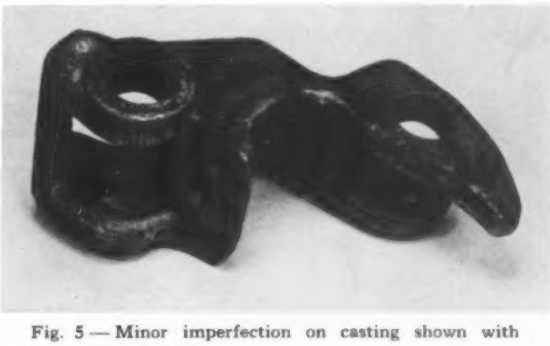


Fig. 5 — Minor imperfection on casting shown with fluorescent penetrant.

Fig. 6 — Large fluorescent penetrant indication on casting, but this one is not serious.

cost. The link between them must be the specification.

CASTING SPECIFICATION

Logically, the only one who best knows the ultimate function of the part is the casting buyer. He is the only one who knows the location of all critical areas and also those not so critical. Unless he has an experienced foundryman on his staff, however, he should make as much use of the foundry's engineers as possible.

Given the necessary information, the foundryman should be able to translate it into an easily castable product. Only the foundryman knows best where the natural parting line should be, how to eliminate as many cores as possible, how to avoid the use of cracking strips and, finally, how to reduce weight. No product is perfect. The more we try to approach perfection without good reason, the more costly that part becomes.

Attempts at perfection adds to the foundryman's cost, the manufacturer's cost and the user's cost. It detracts from our nation's ability to produce. Standards of quality that are satisfactory for the job to be done will win the economic war with competition from other countries.

Part of the answer, at least, is working together on the original design of the product. Until the original pilot run is made and approved, is there really a reason for a rigid specification? It is true, a tentative cost must be agreed upon and critical areas established, but until that first run has been thoroughly checked by both parties concerned, a tentative specification may do just as well as a detailed one.

Such a procedure would give the foundry an opportunity to find out just what they can do for their customer, and how inspection can actually reduce cost and help maintain this required quality. The foundry customer is interested only in a satisfactory product at the lowest possible cost. The foundry must fill these requirements or it will not have an order. If the foundry must maintain 100 per cent inspection, this is a cost consideration. If, on the other hand, it can use inspection to reduce cost and monitor production, then inspection is a worth-while tool.

Given a free hand, the foundryman may later find that a good quality control, rather than a 100 per cent inspection control on a particular part, will yield an equally good product, and the savings thereby earned can now be shared with his customer. Without this cooperation in the beginning, real trouble can be experienced in trying to pour a part not designed to be cast. At a later time, the foundry might even find that a good sampling inspection of each production run is all that is really necessary to maintain a high quality product.

CASE HISTORIES

Can such a system work? Let us find out by looking first at a small malleable foundry, and second, at a large pearlitic foundry. At the first one, small to large runs of critical castings have become a specialty. After each day's run, the foremen get together and select 20 individual castings that have been poured during that day. One might be a casting in real trouble, where the rejection rate has been high. Another might be the pilot run of a new product. Still another may be a long distance run where they have corrected a contour, eliminating a cracking strip or otherwise made a change they feel will be to the customer's benefit. The night shift fluorescent penetrant inspector is instructed to select a random group

Fig. 7 — Minor check on malleable casting corrected with slight contour change.

Fig. 8 — Smooth radius eliminates possible hot checking on malleable casting.

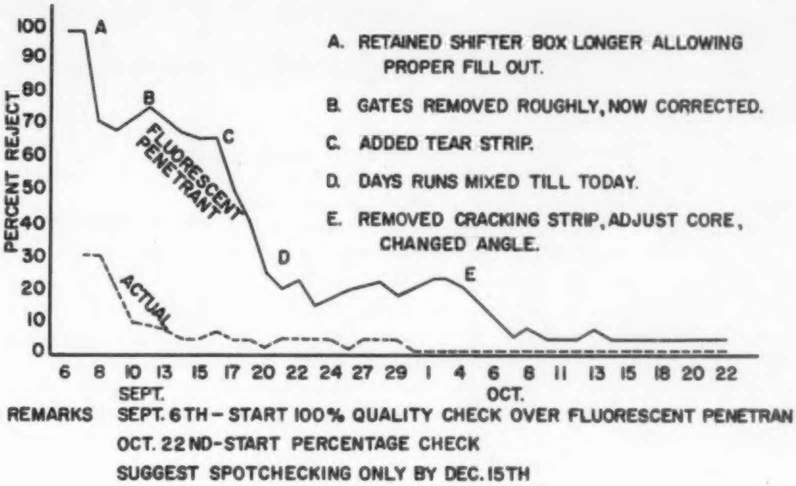


Fig. 9 — Progress report using fluorescent penetrant on high volume run of malleable castings.

of about 25 samples of each casting and give them a thorough inspection.

For their morning meeting, the foremen have a complete report on the findings. Nothing was rejected by the inspection that would not have been rejected by a close visual inspection. The sole purpose of this nightly inspection is to help the foremen come up with answers.

With the facts at hand, corrective measures are taken. Except in rare instances, all castings considered are still quite usable. This procedure is to assure that no casting ever goes out of control, by catching minor imperfections before they become serious and doing something about them. Each foreman is called upon for his ideas which will eventually mean more profit for the foundry, better designed and lower cost castings for their customers.

Production Foundry Procedure

The production foundry, on the other hand, follows a slightly different fluorescent penetrant procedure since they have high volume rather than large variety. More emphasis is given to the best possible design from the beginning. On any new casting that warrants it, a quality control chart is made up for the beginning production run, as shown in Fig. 9.

One particular arm was critical enough to warrant a 100 per cent quality control check over their production fluorescent penetrant machine. The first two day's results were not good. Almost every casting had some slight imperfection. Note, however, that after salvage, 70 per cent were still found perfectly usable. After determining the type of defects encountered, the inspection group got together and ran down the major contributing factor. A shifter box was being yanked away sideways too quickly, removing sand from around the gate. This caused the casting to cool too quickly resulting in poor fill out. It was suggested to production that the shifter box be retained a bit longer. This caused a sharp drop in inspection rejects. After salvage, the final rejectable group dropped to 10 per cent.

Over the next few weeks, two more corrections were made. Figure 10 shows their method of providing feed-back information. At point *B* it was found that the gates were being removed too roughly. This situation was corrected. At point *C*, they added a tear strip to eliminate a minor, though possibly important, discontinuity, should it ever get out of control. Note at this point that although the inspection rejects were still at 65 per cent, the actual rejects were now down to almost 5 per cent. Finally, at point *E* the cracking strip added formerly was removed by adjusting the core and changing one angle slightly.

With production now under control, for a full two week period, the 100 per cent fluorescent penetrant inspection was replaced by a standard quality control sampling check. Even though the fluorescent penetrant with conveyor processing was almost automatic, cost could still be reduced. As shown on this particular chart, if all went well they intended to reduce in-

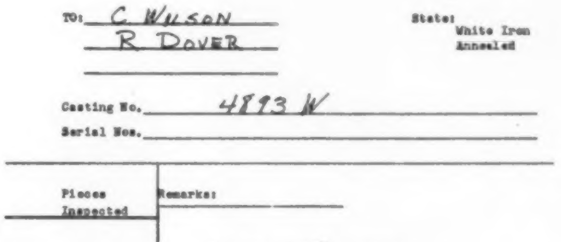

TO: C. Wilson
R. Dover
State: White Iron Annealed
Casting No. 4893 W
Serial Nos.
Pieces Inspected: 210
Remarks: HOT TEARS NEAR OUTSIDE CORNER. SUGGEST HEAVY UP SECTION
Acceptable Pieces: 205
Date 4/9/58
Checked by B. K.

Fig. 10 — Daily feed-back information in a malleable foundry.

spection hours even further by later going to a sampling inspection. Control, rather than a rigid inspection specification is the answer to keeping costs low.

CONCLUSIONS

Next time you are considering making a change to reduce costs, look around for a casting application. It might be a bracket, steering arm, gear, crankshaft, camshaft or rocker arm. Talk it over with the foundry. If it can not be poured economically, they will be the first ones to tell you. Have your engineers work closely with them on the pilot run to make sure your final specification is something you can both live with. Doing this, you will both be saving money in the long run. Whether it be a yoke, a connecting rod or a motor lift bracket, leave the final decision on inspection up to the foundry.

If the part is so critical that you feel it demands 100 per cent inspection despite their rigid inspection system, and there are some of these, the foundry will certainly oblige. But it is only fair that you should pay for these extra inspection hours. Once you are satisfied they are doing the job promised, relax this added requirement.

ACKNOWLEDGMENT

Grateful acknowledgment is given to the Cleveland Works of National Malleable and Steel Casting Co. for many of the photographs and charts used in this presentation. Additional data, help and encouragement were also furnished by Auto Specialties Manufacturing Co., St. Joseph, Mich., and Dalton Foundry, Warsaw, Ind., as well as several other members of the American Foundrymen's Society.

Competition Starts in Annual Memorial Apprentice Contest

■ Competition opens Oct. 1 in the 1960 AFS Robert E. Kennedy Memorial Apprentice Contest and will close April 8. On the basis of past contests, more than 500 patterns and castings will be entered in local competition and over 100 in national judging.

National prizes are awarded in wood patternmaking, metal patternmaking, gray iron molding, steel molding and non-ferrous molding. Three winners are named in each division and receive cash prizes of $100, $75 and $50. First place national winners will have their first-class round-trip transportation paid to the National Convention to be held in Philadelphia.

Eligibility

Competition is open to apprentices and learners, whether or not an apprentice training program is in effect. Eligibility is restricted to not more than five years patternmaking experience and four years molding experience. Membership in AFS is not required from the entrant or his employing company.

Local Contests

Three types of local competition are conducted.

LOCAL CHAPTER CONTESTS—Sponsored by local AFS Chapters. Plant contests within the chapter's area must clear through the local chapter contest. Three winning entries from each of the five divisions are entered in national competition.

INTER-PLANT CONTESTS—If three or more plants participate in a local elimination contest, as an inter-plant contest or local chapter contest, the best three entries in each division may be entered in national contest.

INDIVIDUAL PLANTS—Where an individual plant conducts a local elimination contest for its own employees, only one entry will be accepted from each division in national competition.

Contest Liason

All chapters and plants holding local elimination contests must furnish promptly to the AFS Central Office the name of one person to act as the official contact for all correspondence concerning the contest.

Prior to actual receipt of entries for judging, all contest activities and correspondence should be addressed only to the AFS Education Director, Golf & Wolf Roads, Des Plaines, Ill.

At the time patterns or blueprints are requested for local contests, the AFS Central Office must be furnished with the full names, companies and respective divisions of entry of all intended contestants. The official numbered identification tags for use all contestants cannot be provided until such information is received, since all entry numbers are identified only at the AFS Central Office.

Ductile Iron Executive Committee Makes Plans

Future plans for the Ductile Iron Division were made at an August meeting of the executive committee. Left to right: **H. W. Ruf,** Grede Foundries, Inc., Milwaukee; **David Matter,** Ohio Ferro Alloys, Canton, Ohio; **Dallas Marsh,** Cooper-Bessemer Corp., Mt. Vernon, Ohio; AFS Technical Director, **S. C. Massari. Eric Welander,** John Deere Malleable Works, East Moline, Ill.; **H. G. Haines,** Woodruff & Edwards, Inc., Elgin, Ill.; **C. K. Donoho,** American Cast Iron Pipe Co., Birmingham, Ala.; **Harry Bishton,** International Harvester Co.; **A. J. Fruchtl,** James B. Clow & Sons, Inc., Coshocton, Ohio; **A. H. Rauch** Deere & Co., Moline, Ill.

AFS 1896

news and views

CONTENTS

1960 Show to Unveil Production Advances

■ Foundries' greatest technical advances will come within the next decade. Although considerable progress has been made since World War II, advances will be at an exponential rate in the coming ten years, say many leaders of the castings industry.

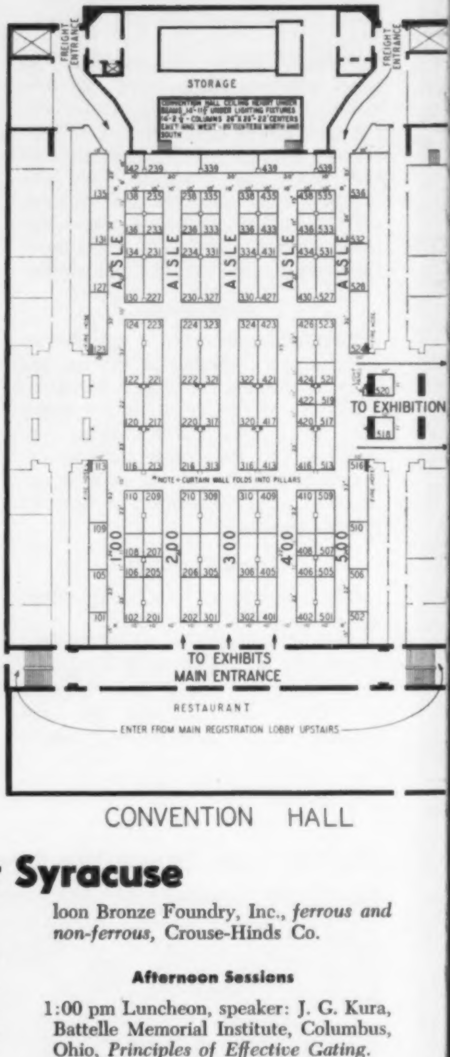
New metalcasting frontiers will be established by the processes and production techniques scheduled for unveiling at the AFS 1960 Foundry Show.

For five days, May 9-13, the Foundry Show will provide foundry equipment manufacturers and suppliers an opportunity to tell, sell and show their products for the lowest advertising dollar. Exhibitors will attain maximum effectiveness in contacting more foundrymen during these few days than possible in several months of traveling.

Foundrymen will be able to efficiently investigate the latest materials, processes and equipment—all will be concentrated in several acres of air-conditioned comfort.

Floor plans, space applications and pertinent information on the Foundry Show have been mailed. Assignment of space has started. AFS Exhibit Manager W. N. Davis reminds exhibitors to make their applications early to obtain the space of their choice.

A total of 100,000 square feet of space will be available in the air-conditioned Philadelphia Convention Hall-Auditorium.



CONVENTION HALL

Empire Regional Conference Oct. 1-2 at Syracuse

■ Technical sessions, luncheons, a banquet and plant visitations comprise the program for the Empire State Regional Foundry Conference to be held Oct. 1-2 at Drumlin's Country Club, Syracuse, N. Y.

Don J. Merwin, Orinskany Malleable Iron Co., N. Y., is general conference chairman and R. P. Watson, Chicago Pneumatic Tool Co., Utica, N. Y., is program chairman.

The program:

THURSDAY, OCT. 1

Morning Sessions

9:00 am *Registration*, Drumlin's Country Club.
9:30 am *Plant Visitations*: *non-ferrous*—Oberdorfer Foundries, Inc., and Meloon Bronze Foundry, Inc.; *ferrous and non-ferrous*, Crouse-Hinds Co.

Afternoon Sessions

1:00 pm *Luncheon*, conference welcome, Syracuse Mayor A. A. Henninger.
2:30 pm *Epoxy Resin Seminar*, presented by staff of Tylene Plastics Co.
2:30 pm *Sand Seminar*, Victor Rowell, Harry W. Dietert Co., Detroit.
5:00 pm *What Does the Casting Designer Expect from the Foundryman?*, T. O. Kuivinen, Cooper-Bessemer Corp., Mt. Vernon, Ohio.
7:00 pm *Banquet*, speaker: Newell Brown, U.S. Assistant Secretary of Labor.

FRIDAY, OCT. 2

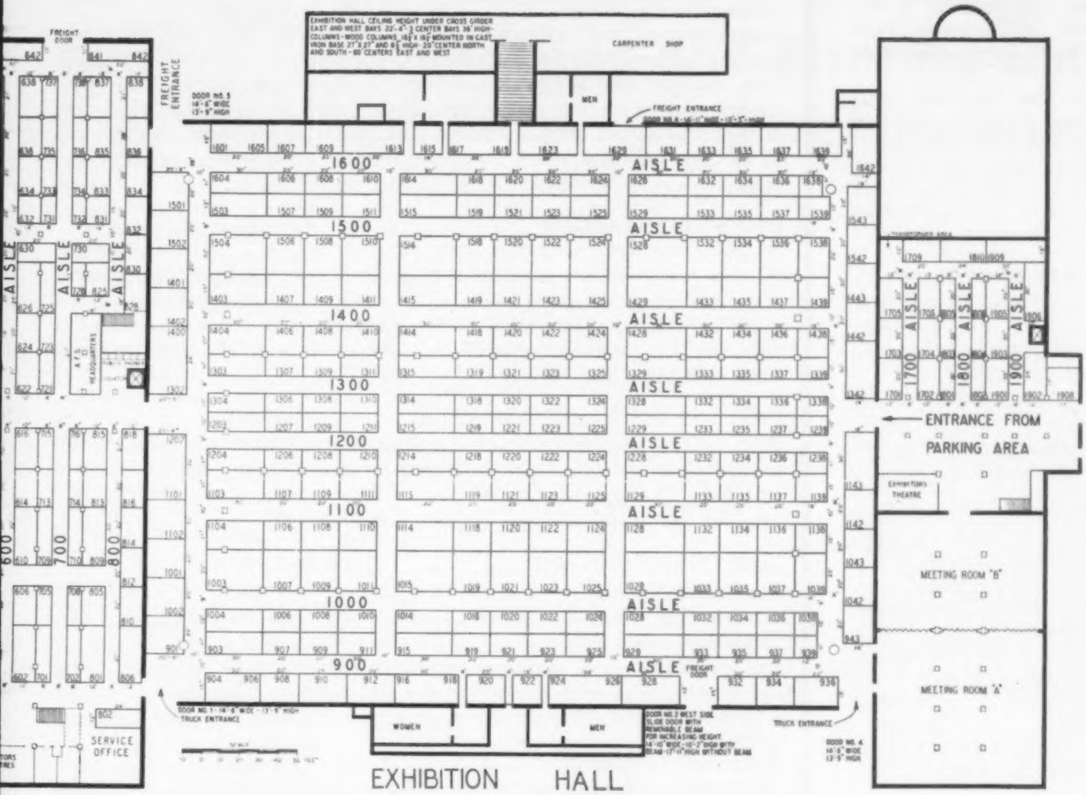
Morning Sessions

9:00 am *Registration*, Drumlin's Country Club.
9:30 am *Plant Visitations*: *non-ferrous*—Oberdorfer Foundries, Inc., and Meloon Bronze Foundry, Inc., *ferrous and non-ferrous*, Crouse-Hinds Co.

Afternoon Sessions

1:00 pm Luncheon, speaker: J. G. Kura, Battelle Memorial Institute, Columbus, Ohio, *Principles of Effective Gating*.
2:30 pm *Epoxy Resin Seminar*, presented by staff of Tylene Plastics Co.
2:30 pm *Sand Seminar*, Victor Rowell, Harry W. Dietert Co., Detroit.
3:00 pm *Gray Iron*, Walter Sokolowski, Remington Rand Co., Div. Sperry Rand Corp., Ilion, N.Y.
4:00 pm *Gating and Risering of New Alloys*, Joseph Allen, Federated Metals Div., American Smelting & Refining Co., Newark, N.J.

A sports program consisting of golf or bowling has been arranged for those not participating in the morning plant visitations.



Nominating Group to Select Candidates for Election at AFS 1960 Convention

■ A nominating committee to select officers and directors for election at the 1960 Annual Business Meeting of the American Foundrymen's Society was named at the August meeting of the Society's Board of Directors.

Six committee members were selected from lists submitted by chapters eligible this year to suggest members. These six, together with the two immediate past presidents will meet Dec. 7 in Chicago to nominate a president, vice-president and six directors, endeavoring as prescribed by AFS By-Laws . . . "To provide equitable and constant regional representation and . . . representative for the several branches of the castings industry.

Members of the nominating committee are:

Past-President L. H. Durdin, Dixie Bronze Co., Birmingham, Ala., chairman.

Past-President Harry W. Dietert, Harry W. Dietert Co., Detroit.

S. W. Chappell, Electric Boat Div., General Dynamics Corp., Groton, Conn. Representing Region 1—Chapter Group A, Connecticut Chapter—Brass & Bronze and Aluminum.

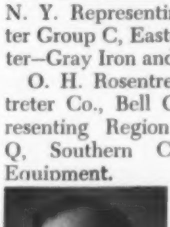
A. H. Hinton, Aluminum Co. of America, Cleveland. Representing Region 3—Chapter Group F, Northeastern Ohio—Aluminum.

A. V. Martens, Pekin Foundry & Mfg. Co., Pekin, Ill. Representing Region 5—Chapter Group M, Central Illinois Chapter—Gray Iron.

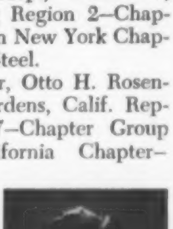
M. B. Parker, Sr., M. B. Parker Co., Memphis Tenn. Representing Region 6, Chapter Group O, Mid-South Chapter—Gray Iron, Brass & Bronze, Aluminum.

G. W. Poirier, Adirondack Steel Casting Co., Div. Consolidated Foundries & Machine Corp., Watervliet, N. Y. Representing Region 2—Chapter Group C, Eastern New York Chapter—Gray Iron and Steel.

O. H. Rosentreter, Otto H. Rosentreter Co., Bell Gardens, Calif. Representing Region 7—Chapter Group Q, Southern California Chapter—Equipment.



H. W. Dietert



L. H. Durdin

Remaining AFS-T&RI Courses Show 5 Ways To Cut Costs

■ Five courses, ranging from plant safety and preventative maintenance to sand technology and the latest in die casting and permanent molding, remain in the AFS-Training & Research Institute 1959 program. Four will be held in Chicago and one in Milwaukee.

Frequent criticism has been made within the foundry industry for lagging in safety and preventive maintenance programs. Problems and recommended programs leading to lower costs will be made at two October courses to be held in Chicago.

Safety & Reduced Costs

NOISE — Legal aspects, physics of noise, physiology of hearing and hearing loss, foundry noise exposures, engineering control of noise.

WORKMEN'S COMPENSATION — Basic philosophy, types of laws, insurance, employer's responsibility, statutory provisions, inequities, how industrial commissions function.

OCCUPATIONAL DISEASE — Silicosis, siderosis, lead poisoning, metal fume fever, beryllium poisoning, dermatitis, treatments, aluminum therapy, facts and fallacies concerning occupational diseases.

VENTILATION — General principles, exhaust hoods, fans, duct work, efficiencies, testing and maintenance of exhaust systems, dust collectors.

HEATING — The right and wrong way, radiant heat demonstration, also movie.

INSTRUCTORS — J. J. Bloomquist, Employers Mutuals of Wausau; Eugene L. Walsh, International Harvester Co.; Herbert J. Weber, AFS Director of Safety, Hygiene & Air Pollution; William Tracy, Sturtevant Div., Westinghouse Electric Corp.; Kenneth Robinson, General Motors Corp.; George Stoecker, General Motors Corp.; Kenneth M. Smith, Caterpillar Tractor Co.; Floyd E. Frazier, National Association of Mutual Casualty Companies; Paul Whitaker, Allis-Chalmers Mfg. Co.; Ralph Betterley, AFS Training & Research Institute Training Supervisor.

Preventive Maintenance

The second course, *Preventative Maintenance*, includes a discussion of the philosophy of preventative maintenance and why a program should be instituted. Other subjects are:

SETTING UP THE PROGRAM — Maintenance analysis of plant equipment, inspections, spare parts, records and forms and accounting.

OPERATING THE PROGRAM — Classification of maintenance, use of records, procedures and maintenance materials and equipment.

EQUIPMENT MAINTENANCE PROBLEMS — Auxiliary equipment, ventilation, air and safety, electrical and controls, molding and core machines, materials handling and physical plant.

Two courses will be given in November, *Permanent Mold & Die Casting* and *Sand Control & Technology*. The latter requires some experience in sand testing, control and technology.

Industrial Engineering, to be given Dec. 7-11 at Milwaukee, is the final course of 1959.

1959 T&RI-AFS Courses

Oct.-Dec.

Subject and Description — ***Dates***

Cutting Hidden Costs ....**Oct. 5-7**
Demonstration and instruction course on savings that can be made through a knowledge of Workmen's Compensation, ventilation, radiant heat, occupational disease, safety in plant design. Plants have little control over insurance premiums. These costs represent only 25 per cent of the actual costs sustained. Informed management can control 75 per cent of these costs. Designed for top management, supervisors, engineers and safety men. Course SAF1A, $60, Chicago.

Preventive Maintenance ....**Oct. 26-28**
Intensive instruction on the "why" and "how" of a preventive maintenance program. Danger points in mechanized foundries having automatic and semi-automatic equipment. Cutting costs and reducing "down time" with an adequate maintenance program. Valuable assistance and guidance for foremen, supervisors, superintendents and management. Course PRM1A, $60, Chicago.

Permanent Mold & Die Casting............**Nov. 9-11**
Both theory and practice are emphasized in course for foundrymen interested in the latest developments in their growing fields. Molding materials, gating and risering, new alloys, methods, equipment and product application. Course PMD1A, $60, Chicago.

Sand Control & Technology..........**Nov. 30-Dec. 4**
Instruction course for foundrymen having had some experience in sand testing, control and technology. Mold wall movement, hot deformation, creep deformation, mold atmosphere, heat transfer, mechanical properties and metal penetration are included. Students bring case problems to class for discussion and solution. Prerequisite: course S1A (Sand Testing) or equivalent experience. Course S2A, $90, Chicago.

Industrial Engineering.....................**Dec. 7-11**
Instruction and workshop course for personnel experienced with basic industrial engineering principles. Practical cost control procedures applied to foundry operations, including work sampling, rating practice and statistical quality control. New techniques in industrial engineering are considered for foundry application. Industrial engineers, cost control personnel, quality control engineers, supervisors and management. Course IE3A, $150, Milwaukee.

Registration

Payment of tuition fees should accompany enrollment applications. Make all reservations only with Director of AFS Training & Research Institute, Golf & Wolf Roads, Des Plaines, Ill. Tel. VAnderbilt 4-0181.

Outline Core Sand Basic Principles

■ Thirty foundry executives, technicians and salesmen attended the AFS-Training & Research Institute *Core Sand Practice* course given Aug. 10-14 in Chicago. This was one of several new courses added to the expanded curriculum.

Eight foundry sand experts donated their time as instructors. Subjects included physical and mechanical properties of sand, handling, mixing and tests; binders core practices. The course concluded with an enumeration of factors contributing to casting losses.

Instructors and their subjects:

T. W. Seaton, American Silica Sand Co., Ottawa, Ill. – core sand.

Wayne Buell, Aristo Corp., Detroit, – drying type oil binders.

William Capehart, Monsanto Chemical Co., Springfield, Mass. – synthetic resins core binders, shell cores.

James Huss, Lauhoff Grain Co., Danville, Ill. – cereal binders.

Joseph Gitzen, Delta Oil Products Co., Milwaukee – special binders, core coatings.

Robert J. Mulligan, Archer-Daniels-Midland Co., Minneapolis – sodium silicate binders.

O. J. Myers, Foundry Products Div., Reichhold Chemicals, Inc., White Plains, N.Y. – semi-self curing binders.

Victor Rowell, H. W. Dietert Co., Detroit – core practices, green core properties, baked core properties, hot core properties, casting losses.

An achievement test was conducted by R. E. Betterley, AFS-T&RI Training Supervisor.

Above—Instructor **Jim Huss,** Lauhoff Grain Co., Danville, Ill., outlines principles of cereal binders.

Below—Instructors **Victor M. Rowell,** Harry W. Dietert Co., Detroit and **William Capehart,** Monsanto Chemical Co., Springfield, Ohio, take part in informal discussion.

Fifty-four foundrymen attended the **AFS-T&RI** Gating and Risering of Castings course held during August in Chicago. Principles applicable to all metals were studied as well as gating and risering of ferrous and non-ferrous metals and malleable iron. Recommendations were given to improve foundry practice.

Gating and Risering Course Draws Largest Enrollment

■ *Gating & Risering of Castings,* with the largest enrollment of the AFS-Training & Research Institute 1959 program was given Aug. 24-26 in Chicago.

Fifty-four enrollees studied basic principles applicable to all metals including discussions on heat transfer and its effect on gating systems, solidification of metals and considerations for controlled solidification. Fundamentals of fluid flow metal as they apply to all metals was also outlined. Two AFS films were shown on studies of horizontal and vertical gating. *Metal Flow in Molds,* from the Institute of British Foundrymen was also presented.

Students also investigated ferrous and non-ferrous castings including optimum pouring time, designing of systems and recommendations.

Instructors and their subjects were:

Dr. W. K. Bock, National Malleable & Steel Castings Co., Cleveland – basic fundamentals including heat transfer as related to castings and fluid flow of metals.

Prof. J. F. Wallace, Case Institute of Technology, Cleveland–gating of ferrous castings including optimum pouring time, designing a gating system, calculations of a gating system conclusions and recommendations. Wallace also presented risering of ferrous systems composed of solidification of gray iron, microporosity, mold materials and risering, casting design and mass, selection of riser size and location, selection of riser necks and dimensions, maintaining riser temperature and conclusions and recommendations.

C. Russell Baker, Albion Malleable Iron Co., Albion, Mich.–Gating and risering of malleable iron covering application of basic fundamentals, operating practices and conclusions and recommendations.

Prof. J. F. Wallace, Case Institute of Technology, Cleveland, outlines fundamentals to AFS-T&RI students.

R. A. Colton, American Smelting & Refining Co., Houston, Texas–gating and risering of non-ferrous alloys–nature of materials under consideration, pouring practice, gating practice, risering of non-ferrous alloys, venting practice, pouring temperature practice and chills, insulators and exothermics.

Name Speakers for Ohio Regional Conference

■ Four Ohio Regional Conference speakers not named in the tentative program have been announced by Publicity Chairman Joseph A. Riley, Jr., Cooper-Bessemer Corp., Mt. Vernon, Ohio.

Additions to the tentative program in September Modern Castings are:

THURSDAY, OCT. 22
(Morning Sessions)

MAINTENANCE – "A Sound Maintenance System Pays Off," Robert L. Page, Central Foundry Div., GMC, Defiance, Ohio.

FRIDAY, OCT. 23
(Morning Sessions)

PATTERN – "Pattern Design," William Weaver, Modern Pattern & Plastics Co., Toledo, Ohio.

MALLEABLE – "Malleable Sand Practice," Gene Medley, Webster Mfg. Co., Tiffin, Ohio.

(Afternoon Sessions)

PATTERN – "Plastic Patterns," M. K. Young, U.S. Gypsum Co., Chicago.

16th New England Regional Foundry Conference to be Held Oct. 16-17

■ New England foundrymen will hold their 19th annual New England Regional Foundry Conference Oct. 16-17 in Kresge Auditorium, Massachusetts Institute of Technology, Cambridge, Mass. General sessions as well as ferrous and non-ferrous meetings will be held.

William N. Ohlson, Draper Corp., Hopedale, Mass., and former president of the AFS New England Chapter is general conference chairman. Ahti A. Erkkinen, AFS New England Chapter President, Fremont Casting Co., Worcester, Mass., is vice-chairman. Stafford W. Chapelle, General Dynamics Corp., Groton, Conn., is program chairman for non-ferrous sessions and John F. Dyer, Shell Process, Inc., West Springfield, Mass., is ferrous program chairman.

Sponsors of the conference are the AFS New England and Connecticut Chapters, AFS M.I.T. Student Chapter, AFS Wentworth Institute Student Chapter, Massachusetts Institute of Technology, Boston Chapter, Non-Ferrous Foundrymen's Association, Connecticut Non-Ferrous Foundrymen's Association, Providence Non-Ferrous Foundrymen's Association, Connecticut Foundrymen's Association, Northeastern University and Tufts University.

FRIDAY, OCT. 16

Morning Sessions

9:00 am *Registration* (Lobby, Kresge Auditorium)

9:45 am *Welcoming Address*: Gordon Brown, Dean of Engineering, M.I.T.

10:00 am *Response*: Ahti A. Erkkinen, President, AFS New England Chapter, Fremont Casting Co., Worcester, Mass.

10:30 am *General Session* (Main Auditorium)
Chairman: Walter A. Helmedach, Wilcox-Crittendon Div., North & Judd Mfg. Co., Middletown, Conn. Co-Chairman: A. W. Sorenson, Wollaston Foundry Corp., North Quincy, Mass.
Importance of Labor Cost Controls, George E. Meyers, management consultant.

Noon *Luncheon*
Chairman: William Naughton, Whitehead Bros., Co., Providence, R. I.
Speaker: George M. Rideout, Babson Reports, Inc., *The Business Outlook for* 1960.

Afternoon Sessions

1:30 pm Organ music, 30 min. (Main Auditorium)

2:00 pm *Non-Ferrous Session* (Little Theatre)
Chairman: Myron Gould, Aluminum Co. of America, Bridgeport, Conn. Co-Chairman: Edward R. Andrews, Hyde Windlass Co., Bath, Me.
Nickel and the Non-Ferrous Metals, G. L. Lee, International Nickel Co., New York.

2:00 pm *Ferrous Session* (Main Auditorium)
Chairman: Fred Bishop, Taylor & Fenn, Inc., Hartford, Conn. Co-Chairman, Romeo J. Lemoine, Fitchburg Foundry Co., Fitchburg, Mass.
Ductile Iron—Production and Control Techniques, Harvey E. Henderson, Lynchburg Foundry Co., Lynchburg, Va.

3:30 pm *General Session* (Main Auditorium)
Chairman: Lewis W. Greensalde, Jr., Brown & Sharpe Mfg. Co., Providence, R.I. Co-Chairman: James Robinson, United Shoe Machinery Co., Beverly, Mass.
Occupational Diseases in Foundrymen —Fact and Fallacy, H. J. Weber, AFS Director of Safety, Hygiene & Air Pollution Control Program.

5:00 pm *Social Hour*, (M.I.T. Faculty Club)

6:30 pm *Conference Dinner* (M.I.T. Faculty Club)
Chairman: Prof. Howard F. Taylor, M.I.T. Co-Chairman: Thomas I. Curtin, Jr., Waltham Foundry Co., Waltham, Mass.
Speaker: "Swede" Nelson.

SATURDAY, OCT. 17

Morning Sessions

8:30 am *Registration* (Lobby, Kresge Auditorium)

9:30 am *General Session* (Main Auditorium)
Chairman: Harold Mattioli, Whitin Machine Co., Whitinsville, Mass. Co-Chairman: Albert Mililli, General Electric Co., Everett, Mass.
Methods of Melting, Fred C. Barbour, Republic Steel Corp., Cleveland.

11:00 am *Non-Ferrous Session* (Little Theatre)
Chairman: Edgar Gotthold, Gorham Mfg. Co., Providence, R.I. Co-Chairman: Franklin Volpe, Jr., Somerville Machine & Foundry Co., Somerville, Mass.
Aluminum Casting Quality Control, D. L. LaVelle, American Smelting & Refining Co., South Plainfield, Mass.

11:00 am *Ferrous Session* (Main Auditorium)
Chairman: Ray Hull, Springfield Facing Co., Springfield, Mass. Co-Chairman, Gus Bouldry, Whitman Foundry, Inc., Whitman, Mass.
What Alloys Can Do for the Small Iron Foundry, David Matter, Ohio Ferro Alloys Corp., Canton, Ohio.

Noon Luncheon

Afternoon Sessions

2:00 pm *Non-Ferrous Session* (Little Theatre)
Chairman: John O'Sullivan, Merriam Bros., Inc., Boston. Co-Chairman: Frank Zackary, Wilcox-Crittendon Div., North & Judd Mfg. Co., Middletown, Conn.
Obtaining Physical Properties of Aluminum Bronze and Aluminum Manganese Bronze, Raymond D. Turner, Electric Boat Div., General Dynamics Corp., Groton, Conn.

2:00 pm *Ferrous Session* (Main Auditorium)
Chairman: Charles Pate, Hersey Mfg. Co., Boston. Co-Chairman, William R. Slater, Whitehead Bros. Co., Providence, R.I.
Gating and Risering of Ferrous Castings, John F. Wallace, Case Institute of Technology, Cleveland.

3:00 pm *General Session* (Main Auditorium)
Chairman: H. J. Bruhn, Belcher Malleable Iron Co., Boston. Co-Chairman: Wilber Priester, Rice, Barton Corp., Worcester, Mass.
The Sands of Time Await No Man, Kurt A. Miericke, Baroid Chemicals, Inc., Chicago.

5:30 pm *Smoker & Dinner* (Parker House Roof)

33 Papers at International

■ Thirty-three technical papers from 17 countries will be presented at the 26th International Foundry Congress to be held Oct. 4-10 in Madrid, Spain.

Papers will be presented during three days of the International sponsored by the International Committee of Foundry Technical Associations with the Spanish Institute of Iron and Steel acting as host.

Howard H. Wilder, Vanadium Corp. of America, Chicago, will present the AFS official exchange paper, *Ferro Alloys and Inoculants for the Production of High-Strength Gray Cast Iron*. In addition, 15 other official exchange papers will be given.

Countries sponsoring technical papers are: Austria, Belgium, Czechoslovakia, Denmark, France, Germany, Great Britain, India, Israel, Italy, Japan, Netherlands, Norway, Poland, Spain, Sweden, and the United Staes.

Official AFS delegates to the International are Clyde A. Sanders, American Colloid Co., Skokie, Ill., and AFS Technical Director S. C. Massari.

C. A. Sanders

S. C. Massari

Regional Conference Schedule

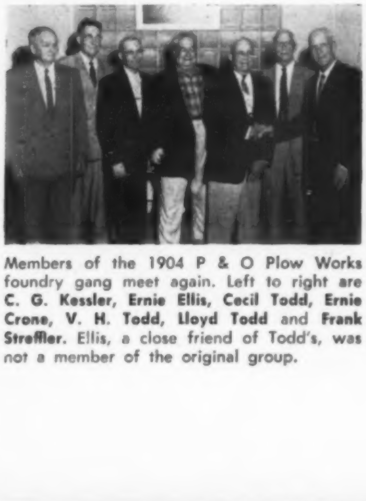
V. H. Todd Completes 55 Years in Foundries

■ A 55-year career started by Virgil H. Todd in 1904 at the age of 16 in the old P & O Plow Works, Canton, Ill., ended in June at the Rockford Brass Works, Rockford, Ill. Not much was said at his leaving but on July 18, more than 200 friends and employees staged a surprise party for Todd.

The program, tracing events in Todd's life, was written by a nephew, K. C. Kessler, Ken-Ray Brass Products, Inc., Vermont, Ill. Six of the eight living members of the old 1904 foundry gang attended. In addition to Todd there were his brothers Cecil and Lloyd, C. G. Kessler, Frank Streffler and Ernie Crone.

Todd, a photographer most of his life, was presented with a camera and accessories and a new auto.

Mrs. Dorothy Owens, president, Rockford Brass Works, Rockford, Ill., congratulates **V. H. Todd** on 55 years in the foundry industry at a surprise party. Others are a nephew, **K. C. Kessler,** president, Ken-Ray Brass Products, and **Marcus J. Honl,** vice-president, Rockford, Brass.



Members of the 1904 P & O Plow Works foundry gang meet again. Left to right are **C. G. Kessler, Ernie Ellis, Cecil Todd, Ernie Crone, V. H. Todd, Lloyd Todd** and **Frank Streffler.** Ellis, a close friend of Todd's, was not a member of the original group.

Oct. 1-2 — Empire State Regional Foundry Conference

Place: Drumlins Country Club, Syracuse N.Y.

Sponsors: Central New York, Eastern New York, Western New York, Rochester, Eastern Canada, Northwestern Pennsylvania.

General Chairman: Don J. Merwin, Oriskany Malleable Iron Co., Oriskany, N.Y.

Program Chairman: Robert P. Watson, Chicago Pneumatic Tool Co., Utica.

Oct. 2-3 — Northwest Regional Foundry Conference

Place: Benjamin Franklin Hotel, Seattle, Wash.

Sponsors: British Columbia, Oregon, Washington Chapters, Oregon State College Student Chapter.

General Chairman: Wm. K. Gibb, Atlas Foundry & Machine Co., Tacoma, Wash.

Program Chairman: Harold Wolfer, Puget Sound Naval Shipyard, Bremerton.

Oct. 8-9 — Michigan Regional Foundry Conference

Place: Pantlind Hotel. Grand Rapids, Mich.

Sponsors: Central Michigan, Detroit, Saginaw Valley and Western Michigan Chapters.

General Chairman: David I. Jacobson, Grand Haven Brass Foundry, Grand Haven, Mich.

Program Chairman: Vern J. Sadler, Jr., General Foundry & Mfg. Co., Flint.

Oct. 16-17 — New England Regional Foundry Conference

Place: Massachusetts Institute of Technology, Cambridge, Mass.

Sponsors: New England Chapter, Massachusetts Institute of Technology Student Chapter.

Chairmen:. Ferrous: J. F. Dwyer, Shell Process, Inc., West Springfield, Mass.

Non-Ferrous: S. W. Chappell, General Dynamics Corp., Groton, Conn.

Program Chairman: William N. Ohlson, Draper Corp., Hopedale, Mass.

Oct. 22-23 — Ohio Regional Foundry Conference

Place: Deshler-Hilton Hotel, Columbus, Ohio.

Sponsors: Canton, Central Ohio, Cincinnati, Northeastern Ohio and Toledo Chapters.

General Chairman: Daniel E. Krause, Gray Iron Research Institute, Columbus.

Oct. 29-30 — Purdue Cast Metals Conference

Place: Purdue University, Lafayette, Ind.

Sponsors: Central Indiana, Michiana and Purdue University Student Chapter.

General Chairman: Dallas F. Lunsford, Perfect Circle Corp., Hagerstown, Ind.

Program Chairman: Howard B. Vorhees, manufacturers' agent, Mishawaka.

Nov. 20-21 — East Coast Regional Foundry Conference

Place: Statler-Hilton Hotel, New York.

Sponsors: Philadelphia, Chesapeake and Metropolitan Chapters.

General Chairman: James S. Vanick, International Nickel Co., New York.

Program Chairmen: Gray Iron and Ductile Iron, H. C. Winte, Florence Pipe Foundry & Machine Co., Florence, N. J.;

Non-Ferrous, Wm. H. Baer, Dept. of the Army, Ft. Belvoir, Va.;

Steel, F. B. Herlihy, American Brake Shoe Co., Mahwah, N. J.

Feb. 11-12 — Wisconsin Regional Foundry Conference

Place: Hotel Schroeder, Milwaukee.

Sponsors: Wisconsin Chapter in cooperation with University of Wisconsin.

General Chairmen: Bradley Booth, Carpenter Bros., Inc., Milwaukee, Prof. P. C. Rosenthal, University of Wisconsin.

Program Chairmen: General Meetings, Eric M. Sobota, Wisconsin Electric Power Co., Milwaukee;

Sectional Meetings, V. A. Guebhard, Jr., International Harvester Co., Milwaukee.

Feb. 18-19 — Southeastern Regional Foundry Conference

Place: Hotel Thomas Jeffereson, Birmingham, Ala.

Sponsors: Birmingham, Tennessee and University of Alabama Student Chapter.

General Chairmen: J. R. Cardvell, Stockham Valves & Fittings, Inc., Birmingham, Ala.; Charles E. Seaman, Crane Co., Chattanooga, Tenn.

Program Chairman: Ernest Finch, American Cast Iron Pipe Co., Birmingham, Ala.

Four AFS Chapters Sponsor Michigan Regional Foundry Conference Oct. 8-9

■ Ferrous, non-ferrous and general sessions will be conducted during the two-day Michigan Regional Foundry Conference to be held Oct. 8-9 at the Pantlind Hotel, Grand Rapids, Mich.

Conference general chairman is David I. Jacobson, Grand Haven Brass Foundry, Grand Haven, Mich. Program chairman is Vern J. Sadler, Jr., General Foundry & Mfg. Co., Flint, Mich.

The conference is sponsored by the AFS Central Michigan, Detroit, Saginaw Valley and Western Michigan Chapters.

THURSDAY, OCT. 8

Morning Sessions

9:30 am to Noon — GENERAL SESSION, Panel Discussion—*Cleaning Castings from Shakeout to Shipping.* *Blasting*: G. O. Pfaff, Wheelabrator Corp., Mishawaka, Ind. *Grinding*: B. J. Chenevert, Ford Motor Co., Detroit. *Milling*: R. C. Wigger, Ransohoff Co., Hamilton, Ohio. *Quality*: R. Leppien, Central Foundry Div., GMC., Saginaw, Mich.

Afternoon Sessions

Noon to 1:15 pm — *Noise Abatement*, Herbert J. Weber, AFS Director of Safety, Hygiene & Air Pollution Control, Luncheon Speaker.

1:30 pm to 3:00 pm — FERROUS SESSION. *Water-Cooled Cupolas, Construction and Current Trends*, Jack Goudzwaard, Neenah Foundry Co., Neenah, Wis.

1:30 pm to 3:00 pm — NON-FERROUS SESSION *Controlled Production*, L. E. Capek, Du-Wel Metal Products, Inc., Bangor, Mich. *Metal Efficiency in Magnesium Casting Operations*, F. C. Bennett, Dow Chemical Co., Midland, Mich.

3:00 pm to 4:30 pm — FERROUS SESSION. *High-Strength Cast Irons and Nodular*, R. A. Clark, Union Carbide Metals Co. Div., Union Carbide Corp., Cleveland. *Malleable Base Spheroidal Iron*, F. B. Rote, Albion Malleable Iron Co., Albion, Mich.

3:00 pm to 4:30 pm — NON-FERROUS SESSION. *Synthetic Sands for Non-Ferrous Casting*, W. L. Adams, Eastern Clay Dept., International Minerals & Chemical Corp., Skokie, Ill. *Combustion and Melting in Non-Ferrous Foundries*, A. C. Schmid, Joseph Dixon Crucible Co., Jersey City, N. J.

BANQUET

FRIDAY, OCT. 9

Morning Sessions

9:00 am to 10:15 am — *Proper Gating Through the Use of Cobalt 60*, K. E. Spray, Central Foundry Div., GMC, Saginaw, Mich.

10:45 am to 12:00 am — *Directional Solidification as Related to Design*, W. P. Dudley, Ohio Steel Foundry Co., Lima, Ohio.

11:00 am — Students will retire to their special session. *Job Potentials and Opportunities in the Foundry Industry*, E. Frens, General Electric Co., Foundry Div.

Afternoon Sessions

Noon to 1:15 pm — *Atomic Blast — A Pattern for Survival*, Luncheon Speaker, F. B. Porzel, Armour Research Foundation, Chicago.

1:30 pm to 3:00 pm — *Diversification for Foundry — Means of Survival*, Panel Discussion. *Diversification of Processes* — Sam Hodler, Golden Foundry Co., Columbus, Ind. *Diversifying the Customer* — Wm. Truckenmiller, Albion Malleable Iron Co., Albion. *Need and Willingness to Serve the Customer*, Walter Szott, Central Foundry Div., GMC, Danville, Ill.

Foundrymen bid good-bye to C. A. Sanders on departure to Europe and International Foundry Congress. Left to right are **Bradley Booth, O. J. Myers, R. J. Maddison, C. B. Somers, A. Williamson, C. A. Sanders, J. S. Vanick, B. P. Wallace, R. B. Fischer, J. P. O'Neill, Jack Miller.**

Courses given during the 1959 AFS-Training & Research Institute program were reviewed and new courses studied at July meeting of the AFS-T&RI Course Advisory Committee meeting. Clockwise from left are AFS-T&RI Training Supervisor **R. E. Betterley**; Prof. **J. L. Leach**, University of Illinois, Urbana, Ill.; **Edward Trela**, Apex Smelting Co., Cleveland; AFS-T&RI Director **S. C. Massari, T. E. Barlow**, Eastern Clay Products Dept., International Minerals & Chemical Corp., Skokie, Ill.; **T. T. Lloyd**, Albion Malleable Iron Co., Albion, Mich.; **H. H. Wilder**, Vanadium Corp. of America, Chicago; **Hyman Bornstein**, ex-officio member and Chairman of the AFS-T&RI Trustees; Prof. **John Wallace**, Case Institute of Technology, Cleveland.

Pfeiffer Retires After 56 Years

■ Albert F. Pfeiffer, consultant, foundry and pattern shops, Allis-Chalmers Mfg. Co., Milwaukee, has retired after 56 years in the foundry industry.

A. F. Pfeiffer

Pfeiffer began his career as a patternmaker apprentice in 1902 with Dickson Mfg. Co. Later this Pennsylvania firm was acquired by Allis-Chalmers and Pfeiffer was transferred to the West Allis plant in 1911 where he remained. For many years he was superintendent of pattern shops. He has been active in the AFS Pattern Division and served as its chairman. He also held various offices in the AFS Wisconsin Chapter and also served as its chairman.

In 1955 he was awarded an AFS Life Membership.

chapter news

Eastern New York Chapter

Holds Annual Field Day

■ Approximately 75 members attended the annual field day and outing conducted by the chapter. Door prizes were awarded as well as prizes for contests. *—Leonard C. Johnson*

Pittsburgh Chapter

Golfers Compete for Gold Cup

■ Pittsburgh Chapter golfers competed this year for the golf trophy introduced by the Pennsylvania Glass Sand Corp. Each year the golfer with the lowest score will be presented with an inscribed replica of the award and his name placed on the gold cup. A golfer with the lowest score for three years will retain permanent possession. John V. Scherer, Pittsburgh Steel Foundry, won this year.

Northeastern Ohio Chatper

Elects New Directors

■ Five new directors were recently elected by members of the AFS Northeastern Ohio Chapter. Shown in the photograph, left to right, they are: **Robert Newyear**, A. C. Williams Co.; **Oliver Pels**, Grabler Mfg. Co., **Frank Oklessen**, Motor Patterns Co.; **Emil Chirila**, Ford Motor Co.; and **R. A. Green**, Eastern Clay Products Dept., International Minerals & Chemical Corp. **—Harold Wheeler**

Chesapeake Chapter

Plans Year's Activities

■ Chapter officers, directors and committee chairmen met in July to outline plans for the coming year's program. The program started with plant visitations in York, Pa. Those visited were Columbia Malleable Co., York Chain & Cable Co. and Cochrane Foundry. *—V. R. Chastang*

Approximately 100 members of the **Central Ohio Chapter** attended the annual picnic held in June. Drawing door prize stubs is Chapter Chairman **Dallas M. Marsh,** Cooper-Bessemer Corp., Mt. Vernon, Ohio. Holding box is picnic chairman **Paul E. Eubanks,** Ohio Steel Foundry Co., Springfield, Ohio. In background is **John Dusthimer,** Keener Sand & Clay Co., Columbus, Ohio. **—Joseph A. Riley, Jr.**

Oregon Chapter's outgoing Chapter Chairman **Robert M. Burns,** Pacific Light Metals Foundry Co., Portland, Ore., was awarded transistor radio at June meeting.

Outgoing **Western New York** Chairman **L. B. Polen** (right) Allegheny Ludlum Steel Corp., presents gavel to 1959-60 chapter chairman **A. J. Heysel,** E. J. Woodison Co., Buffalo, N.Y. **—Don Kreuder**

Golf committee checking a players' score at the annual **Wisconsin Chapter** picnic. Program included golf, blowing, prizes, cards, lunch and dinner. Henry Seeboth, H. Cohn & Sons, Milwaukee, served as chairman and Don Gerlinger, Walter Gerlinger, Inc., Milwaukee, was co-chairman. **—Bob DeBroux**

Frank Benkovitch, bowling demonstrator, shows **Wisconsin Chapter** members at annual picnic how to improve their bowling scores.

Two visiting firemen at the **Canton** picnic were AFS National Director **Fred J. Pfarr,** Lake City Malleable Co., Cleveland and **A. H. Hinton,** Aluminum Co. of America, Cleveland, Chairman of the Northeastern Ohio Chapter.

Quad City Chapter

Holds Pre-Season Meeting

■ Officers and directors held a preseason meeting in August to arrange the annual program. A coffee talk will be held prior to each technical discussion. *—William Ellison*

Shown at **Canton** picnic are Chapter Chairman **Raymond J. Bossong,** American Steel Foundries, former Canton Chapter Chairman **Wendell Snodgrass** and **Charles Scoville,** Babcock & Wilcox Co.

Shown at dinner held following outdoor activities of the **Chicago** annual picnic are **H. C. Weimer** and **H. G. Schlichter,** Beardsley & Piper Div., Pettibone-Mulliken Corp., and **W. W. Moore,** Burnside Steel Foundry Co. —**George DiSylvestro**

Relaxing at **Canton** picnic are **Fred Pizzedaz,** American Steel Foundries; Chapter Director **Gale Shackelford,** W. L. Jenkins, Co.; co-chairman, prizes, **Bob Epps,** Thiem Products, Inc., **Dave Born,** American Steel Foundries.

Canton Chapter picnic officials standing are: picnic chairman, **F. A. Dun,** Babcock & Wilcox Co.; treasurer, **Dale Crumley,** Rockwell Mfg. Co.; prizes, **Pat Morgan,** Babcock & Wilcox Co. Seated is **Stanley Zansitis, Hickman,** Williams & Co., golf committee.

Wentworth Institute Student Chapter Officers and instructors meet to plan activities. Left to right in front row are: **F. J. Boylan,** foundry instructor; Chapter Chairman **Anthony Ricci; J. Gerin Sylvia,** faculty advisor. In rear row: Chapter Vice-Chairman **Walter R. LePriore;** Secretary **Matthew J. Faino;** Treasurer **Ronald A. Dubois.**

Relaxing at **Chicago Chapter** picnic are **Jose Acebo** and **Roy Huebener,** American Colloid Co., Chicago; **C. J. Meneghin** and **W. J. Urbanek,** Kensington Steel Co., Chicago.

afs chapter meetings

OCTOBER

Birmingham District . . Oct. 9 . . Thomas Jefferson Hotel, Birmingham, Ala. . . S. F. Carter, American Cast Iron Pipe Co., *"Practical Tips on Cupola Operation."*

British Columbia . . *See Northwest Regional Foundry Conference.*

Canton District . . Oct. 1 . . Town and Country Restaurant, Canton, Ohio . . R. W. Gardner, Dearborn Iron Foundry, Ford Motor Co., *"Quality Control in the Foundry."*

Central Illinois . . Oct. 5 . . Vonachen's Junction, Peoria, Ill.

Central Indiana . . Oct. 5 . . Turner's Athenaeum, Indianapolis.

Central Michigan . . Oct. 21 . . Hart Hotel, Battle Creek, Mich.

Central New York . . *See Empire State Regional Foundry Conference.*

Central Ohio . . *See Ohio Regional Foundry Conference.*

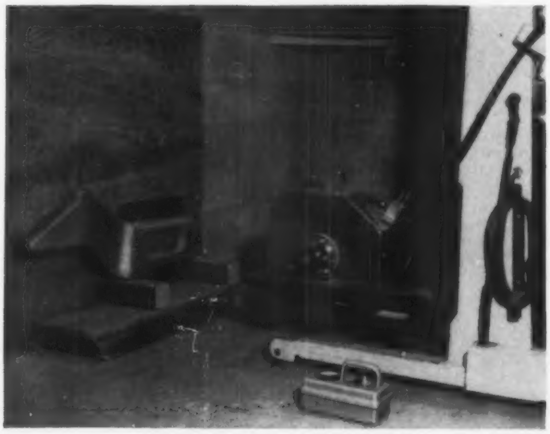
Chesapeake . . Oct. 23 . . Engineers' Club, Baltimore, Md. . . J. D. Allen, Jr., Federated Metals Div., American Smelting & Refining Co., *"New Developments in Non-Ferrous Cast Metals."*

Continued on page 122

Judges for the casting contest at the **Chicago** annual outing were (left) **Leroy Taylor,** Ottawa Silica Sand Co., Ottawa, Ill., contest chairman, and **A. J. Panozzo,** Griffin Wheel Co., Chicago. —**George DiSylvestro**

Caterpillar D8 Tractor with ripper tearing through road material

Rippers really rough it—
Radiography checks their stamina



Ripper Shank being radiographed with cobalt 60 projector

Ripper shanks and clevises at the business end of a high-powered tractor lead a torturous life as they tear through overburden and rock.

So Caterpillar makes sure of their stamina—has them x-rayed at the foundry that casts them. This is the place to show up imperfections—any voids—any inclusions. For here radiography can do two things. It can make sure only physically fit castings go out. It can point the way to improved casting technics resulting in better castings and greater yields.

Foundrymen everywhere—in small plants and large—find radiography a big factor in pleasing customers and building business. If you would like to know more about how it can help you, get in touch with an x-ray dealer or write for a Kodak technical representative to call.

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Read what Kodak Industrial X-ray Film, Type AA, does for you:

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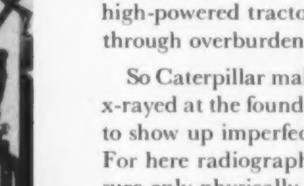

Kodak

Circle No. 164, Page 155-156

chapter meetings

Continued from page 120

Chicago . . Oct. 5 . . Chicago Bar Association, Chicago . . J. W. Macomb, Jr., Inland Steel Co., *"Impact of Waterways on Chicago Industrial Growth."*

Cincinnati District . . Oct. 12 . . Eaton Manor, Hamilton, Ohio . . *"Vertical Gating" Film and Panel Discussion.*

Connecticut . . Oct. 27 . . Waverly Inn, Cheshire, Conn. . . F. C. Barbour, Republic Steel Corp., *"Solidification Patterns of Gray Iron & Ductile Irons."*

Corn Belt . . Oct. 16 . . Cotner Terrace Supper Club, Lincoln, Neb. . . J. Albanese, Acme Resin Corp., *"Resin Binders, Shell & Core Molding Techniques."*

Detroit . . Oct. 1 . . Wolverine Hotel, Detroit . . R. M. Critchfield, GMC, *"New Trends in Casting of Aluminum."*

Eastern Canada . . Oct. 2 . . Mt. Royal Hotel, Montreal, Que. . . J. A. Gitzen, Delta Oil Products Co., *"Core Sand Additives."*

Eastern New York . . Oct. 20 . . Panetta's Restaurant, Menands, N. Y.

Empire State Regional Foundry Conference . . Oct. 1-2 . . Drumlin's Country Club, Syracuse, N. Y.

Metropolitan . . Oct. 5 . . Essex House Hotel, Newark, N. J. . . *Membership Night and Round Table Discussion, "Development of AFS Research Projects."*

Mexico . . Oct. 19 . . Camara Nal. de la Industria Transformacion, Mexico, D. F. . . R. O. Calderon, Metalurgica Ortega, S.A., *"Cast Iron Ingot Mold Technique."*

Michiana . . Oct. 12 . . Felberg's, St. Joseph, Mich. . . R. L. Gilmore, Superior Steel & Malleable Castings Co., *"Casting Design for Survival."*

Michigan Regional Foundry Conference . . Oct. 8-9 . . Pantlind Hotel, Grand Rapids, Mich.

Mid-South . . Oct. 9 . . Claridge Hotel, Memphis, Tenn. . . C. E. Westover, Westover Engineers, *"Mechanization for Small Foundries."*

Mo-Kan . . Oct. 15 . . Kansas City, Kans. . . J. Albanese, Acme Resin Corp., *"Resin Binders, Shell & Core Molding Techniques."*

New England . . *See New England Regional Foundry Conference.*

New England . . *Regional Foundry Conference* . . **Oct. 16-17** . . Massachusetts Institute of Technology, Cambridge, Mass.

Northeastern Ohio . . Oct. 8 . . Tudor Arms Hotel, Cleveland . . H. F. Bishop, Exomet, Inc., *"Exothermic & Insulating Materials."*

Northern California . . Oct. 12 . . Spenger's Cafe, Berkeley, Calif.

Northern Illinois & Southern Wisconsin . . Oct. 13 . . Lafayette Hotel, Rockford, Ill.

Northwest Regional Foundry Conference . . Oct. 2-3 . . Benjamin Franklin Hotel, Seattle.

Northwestern Pennsylvania . . Oct. 26 . . Amity Inn, Erie, Pa.

Ohio Regional Foundry Conference . . Oct. 22-23 . . Deshler-Hilton Hotel, Columbus, Ohio.

Ontario . . Oct. 30 . . Royal Connaught Hotel . . Hamilton, Ont. . . L. B. Knight, Lester B. Knight Associates, *"Modernization in Large & Small Foundry."*

Oregon . . *See Northwest Regional Foundry Conference.*

Philadelphia . . Oct. 9 . . Engineers' Club, Philadelphia . . Dr. J. C. Elgin, Princeton University, *"Education & Industry Today."*

Piedmont . . No Meeting.

Pittsburgh . . Oct. 19 . . Webster Hall Hotel, Pittsburgh, Pa. . . A. A. Evans, International Harvester Co., *"Quality Control in the Foundry."*

Purdue Metals Casting Conference . . Oct. 29-30 . . Purdue University, West Lafayette, Ind.

Quad City . . Oct. 19 . . LeClaire Hotel, Moline, Ill. . . H. J. Weber, AFS, *"Noise—A New Compensation Problem for Foundrymen."*

Rochester . . Oct. 5 . . Manger Hotel, Rochester, N. Y.

Saginaw Valley . . Oct. 1 . . Fischer's Hotel, Frankenmuth, Mich. . . C. C. Sigerfoos, Michigan State University, *"European Foundry Experience."*

St. Louis District . . Oct. 8 . . Edmond's Restaurant, St. Louis . . C. E. Drury, Central Foundry Div., GMC, *"Pouring Effect on Scrap."*

Southern California . . Oct. 9. . . Kaiser Steel Co., Fontana, Calif. . . *Plant Visitation.*

Tennessee . . Oct. 30 . . Wimberly Inn, Chattanooga, Tenn.

Texas . . Oct. 16 . . Menger Hotel, San Antonio, Texas . . *Gray Iron Panel, Moderator*: J. H. Kimes, Jr., Tennessee Products & Chemical Corp.

Continued on page 125

Save Up To 50% In Core Baking Time!

Dexocor yields top results with all ramming processes.

Use Dexocor binder, the amazing new binder for sand molds. Field reports show this *dry* replacement for core oil cuts baking time 30 to 50 percent!*

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Whether you make small or large castings, simple or intricate, you will profit by the properties of Dexocor. One foundry now uses it in 19 different sand and core mixes!

For the full facts on this amazing new binder and technical assistance in adapting it to your special needs, contact our nearest sales office or write direct.

*Source on request

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DEXOCOR® is the perfect teammate for MOGUL® and KORDEK® binders and GLOBE® dextrines

CORN PRODUCTS SALES COMPANY 17 BATTERY PLACE, NEW YORK 4, N.Y.

Circle No. 166, Page 155-156

How to control casting quality:

use quality-controlled alloys from Reynolds Aluminum

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8 Montgomery Street
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One good way to be sure of uniformity and high quality in your aluminum castings is to be sure of the quality of the pig or ingot you use. Many foundries have solved their quality-control problems by using Reynolds Aluminum pig and ingot along with Reynolds technical and consulting services. (You get *more* than metal when you buy from Reynolds.) High standards, painstaking production and inspection methods all assure the consistent high quality of Reynolds casting alloys.

In addition to the large stocks of casting alloys maintained at our producing plants—Jones Mills, Arkansas and Troutdale, Oregon—an important part of Reynolds service to the foundry industry is a nation-wide network of ingot distributors whose extensive stocks are even closer to you. *Reynolds Metals Company, P.O. Box 2346-FL, Richmond 18, Virginia.*

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The Finest Products
Made with Aluminum
are made with
REYNOLDS ALUMINUM

Circle No. 167, Page 155-156

chapter meetings

Continued from page 122

Texas, East Texas Section . . Oct. 23 . . Shreveport, La.

Timberline . . Oct. 14 . . Denver, Colo. . . J. Albanese, Acme Resin Corp., *"Resin Binders, Shell & Core Molding Techniques."*

Toledo . . Oct. 7 . . Heatherdowns Country Club, Toledo, Ohio.

Tri-State . . Oct. 9 . . Joplin, Mo.

Twin City . . Oct. 28 . . Calhoun Beach Hotel, Minneapolis . . G. C. Schelley, Do-All Co., *"Story of the Cutting Edge." Joint Meeting with A. S. M.*

Utah . . Oct. 13 . . Salt Lake City, Utah . . J. Albanese, Acme Resin Corp., *"Resin Binders, Shell & Core Molding Techniques."*

Washington . . *See Northwest Regional Foundry Conference.*

Western Michigan . . Oct. 5 . . Bill Stern's, Muskegon, Mich. . . *Joint Meeting with A.S.M.*

Western New York . . *See Empire State Regional Foundry Conference.*

Wisconsin . . Oct. 9 . . Schroeder Hotel, Milwaukee . . W. L. McGrath, *"The Surprising Case of the I.L.O."*

NOVEMBER

NOVEMBER						
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29	30					

Canton District . . Nov. 5 . . James B. Clow & Sons, Inc., Coshocton, Ohio . . *Plant Visitation.*

Central Illinois . . Nov. 2 . . American Legion Post 2, Peoria, Ill.

Central Indiana . . Nov. 2 . . Turner's Athenaeum, Indianapolis.

Chicago . . Nov. 2 . . Chicago Bar Association, Chicago.

Detroit . . Nov. 5 . . Wolverine Hotel, Detroit . . E. M. Hinze, E. T. Runge Associates . . *"Cutting Costs in the Foundry." Management Night.*

Piedmont . . Nov. 6 . . Statesville, N. C. . . Z. Madacey, Beardsley & Piper Div., Pettibone Mulliken Corp., *"Coremaking & Core Blowing."*

Eastern Canada . . Nov. 6 . . Mt. Royal Hotel, Montreal, Que. . . R. W. Ruddle, Foundry Services, Inc., *"Correct Use & Latest Development of Exothermic."*

The Iron That Bends

by Frank F. Brendler, *Sales Engineer*
Stanley Foundries, Inc.
Huntington Park, Calif.

Ductile iron represents a whole new series of metals. It combines many of the advantages of cast iron—good fluidity, castability and machinability with those of steel—high strength, good fatigue properties, toughness, ductility and wear resistance. To a great degree ductile iron fills the gap which long existed between gray iron and steel.

Ductile iron enables foundries to cast more intricate shapes with thin sections and still maintain the strength and toughness necessary for parts requiring severe service conditions.

TYPICAL APPLICATIONS

You may ask, "What would be some of the most typical applications and why would ductile iron be most suitable?"

Ductile iron is most suitable where castability, shock loading, high fatigue properties and wear resistance are needed. A few typical applications are:

Crankshafts—for internal combustion engines, both diesel and gasoline type. A great many crankshafts used are presently forged, but afford an excellent potential for the sale of ductile iron. A crankshaft requires these basic qualities and ductile iron provides essentially all of them:

1) High mechanical properties
2) High modulus of elasticity
3) Wear resistance
4) High fatigue properties
5) Excellent machinability
6) High dampening effect to reduce noise and vibration.

Gears—for the power transmission equipment used by the agricultural, cement, construction and metalworking industries. Gears generally require:

1) High mechanical properties such as tensile strength and impact resistance
2) Wear resistance
3) Excellent machinability
4) High dampening effect to minimize the noise level
5) Heat treatable to a high hardness—up to 600 Bhn.

Pulleys and Sheaves—for power transmission in the agricultural, construction, mining and electrical industries. The metal best suited for this application should have the following properties:

1) High mechanical properties
2) Wear resistance
3) High modulus of elasticity
4) High dampening effect
5) Good machinability

Ductile iron has all these essential properties.

There are thousands of other good applications, such as valves, gear housings, cams, flywheels, sprockets, hubs, levers, transmission cases, bearing blocks, brackets of all types, etc.

SELLING DUCTILE IRON

Producers are still misapplying ductile iron and overselling it on occasions. We are still allowing the economic ups and downs common to the foundry business to affect our judgment. The old adage, "The foundry business is feast or famine" still holds true. *There is nothing worse than a hungry ductile iron salesman on the loose*. He needs an order to bolster his ego. He becomes blinded by his over-enthusiasm and fails to take that realistic look. He still forgets that his lack of integrity will hurt his company as well as himself.

We still find unqualified salesmen selling ductile iron. This is the fault of management. Let's not send a boy out to do a man's job. This man represents you. The impression he leaves represents that left by his company. Let's make sure it's the right impression by insuring that our field men are well trained and fully qualified. Make sure they have all the necessary tools to work with before sending them into the front lines.

EDUCATE YOUR SALESMEN

How many of us walk through a plant and pass right by excellent ductile applications. It requires a special knack to be able to recognize an object made by a different process or material and be able to visualize its potential in ductile iron. It requires a great deal of inquisitiveness, imagination and product "know how." Let's make sure the salesmen have these qualifications.

We often sell the wrong grade of ductile iron. Incorrect applications cause the user to regard ductile iron as a poor material. A salesman should

always make a thorough study of the part to be made. How will it be used? What is required to make the casting function properly with other relating parts? This will help the foundry personnel determine proper application and will give them a better over-all picture of the function of the castings.

NO CURE-ALL

Ductile iron is an excellent engineering material—but it is not a cure-all. It has its own spot in the spectrum of metals. In the future let's not only make sure it ends up in the right church, but in the right pew as well.

■ Let's produce better ductile iron castings; ship them on schedule at a competitive price. This always helps reassure the users that ductile iron will not only do the job better but more economically as well. It encourages engineers to design many more parts, specifying this amazing new material offering industry—"The iron that bends."

Editor's Note: *This article contains highlights excerpted from a talk presented at the* 1959 *California Regional Foundry Conference.*

OCCURRENCE, PRODUCTION AND USES OF QUALITY SILICA

by L. G. Burwinkel, Jr.
Pennsylvania Glass Sand Corp.
Pittsburgh, Pa.

The mineral silica is quarried in various manners throughout the United States. The Cohansey quartzite in New Jersey is excavated from the bottom of man-made lakes by hydraulic dredging. In central Pennsylvania and northeastern West Virginia, open face quarrying methods are used to mine the famous Oriskany quartzite. Open face quarrying is also used for the deposits of St. Peter quartzite in eastern Missouri and on the important Sharon formation in Ohio and Pennsylvania. Hydraulic processes are used to quarry the St. Peter deposits in central Illinois and the Oil Creek formation in south central Oklahoma. These deposits supply about 90 per cent of industry's requirements for quality silica.

The Oriskany quarry of Pennsylvania Glass Sand Corp. at Berkeley Springs, West Virginia was reported to be the largest open face silica quarry in the world, measuring 400 feet wide, 300 feet high and one mile long. From this quarry, quartzite rocks are transported to the world's largest silica plant and processed into numerous grades of silica ranging from 8 mesh sand to silica flour finer than 325 mesh. After reduction to its original quartz grains, the silica is washed three times, thoroughly dried, accurately screened into uniform grades and vacuum cleaned. The result is pure white, perfectly uniform grades of quality silica sand (99.9% SiO_2).

Silica flour is produced in huge tube mills. Here the silica sand is ground to flour. Tubes are lined with imported Belgian silex blocks and French flint pebbles are used as the grinding media. Accurately controlled air separators classify the fine particles into various grades.

Often called the basic raw material of American industry, quality silica probably has more diversified uses than any other nonmetallic mineral. In fact, our present civilization is so dependent on the innumerable products made from silica—products which guard our health, increase our comfort and enrich our lives—that without this essential mineral the world of today would no longer be modern.

Editor's Note: *This article contains highlights excerpted from a talk presented at the* 1959 *Penn State Foundry Conference.*

foundry trade news

STEEL FOUNDERS' SOCIETY OF AMERICA . . . will hold its annual fall meeting at The Homestead, Hot Springs, Va., September 21 and 22. Guest speakers at their topic will include Dr. M. W. Lightner, U. S. Steel Corp., "Looking Ahead in Steel Research"; J. Keith Louden, Lebanon Steel Foundry, Lebanon, Pa., whose talk "It is Later Than You Think" will analyze the industry's position; and Dr. Pierre Rinfret, Lionel D. Edie & Co., New York, "The Diffusion of Growth." Ross L. Gilmore, society president, will preside at the meetings.

CAST BRONZE BEARING INSTITUTE . . . has been awarded the Certificate of Merit of *American Metal Market* for its work in marketing copper and brass products.

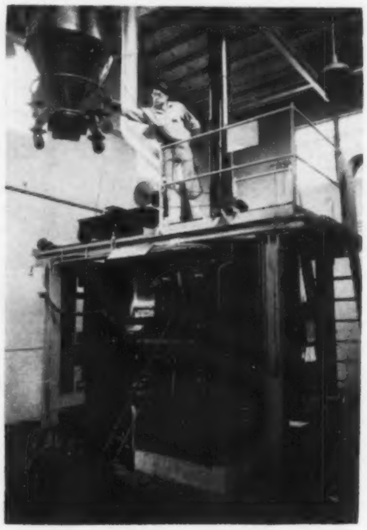
MAGNESIUM ASSOCIATION . . . will hold its 15th annual convention Oct. 19-20 at the Hotel Roosevelt, New York. Theme of the convention is "Magnesium Technology and Trends." Speakers will emphasize the necessity for improving producibility and reliability testing standards and procedures. Exhibits will show component parts and finished products.

FOUNDRY EQUIPMENT MANUFACTURERS ASSOCIATION . . . will hold its 41st annual meeting Oct. 15-17 at the Greenbrier Hotel, White Sulphur Springs, W. Va. Meetings on the opening day will be devoted to product groups consisting of blast cleaning and tumbling, dust and fume control, flasks and accessories, furnace and accessories, material handling and processing and molding and coremaking machines. A panel discussion on Depreciation and Replacement of Foundry Equipment will also be featured. Irwin Such, editor-in-chief, Steel magazine, will be the guest speaker. A president, two vice-presidents, three directors, executive secretary and treasurer will be elected.

Metalmasters, Inc. . . . die casting firm has moved to its new building at 5725 Ravenswood Ave., Chicago.

Hevi-Duty Electric Co. . . . Milwaukee, a division of Basic Products Corp., has purchased Sermax Corp., Milwaukee, manufacturer of special equipment and ovens ranging in size from bench models to large field erected units. Hevi-Duty will continue to manufacture in the Sermax plant.

Eastern Gas & Fuel Associates . . . has completed an expansion of laboratory facilities for research on special coals for iron and steel making at Everett, Mass. Experimenting with coking coal may be done on a scale

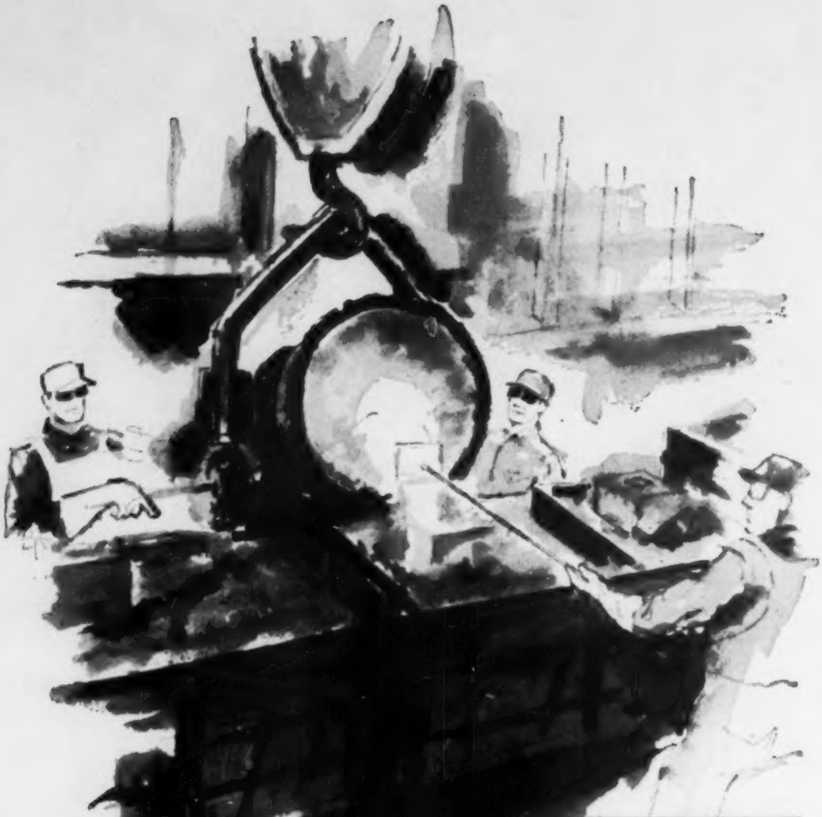


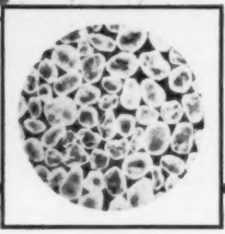
from 1 oz to 500 lb. Oven, shown in picture, has movable sidewall. Dual purpose installation enables researches to study expansion of coal blends during coking process, while also varying other conditions, such as coking temperatures.

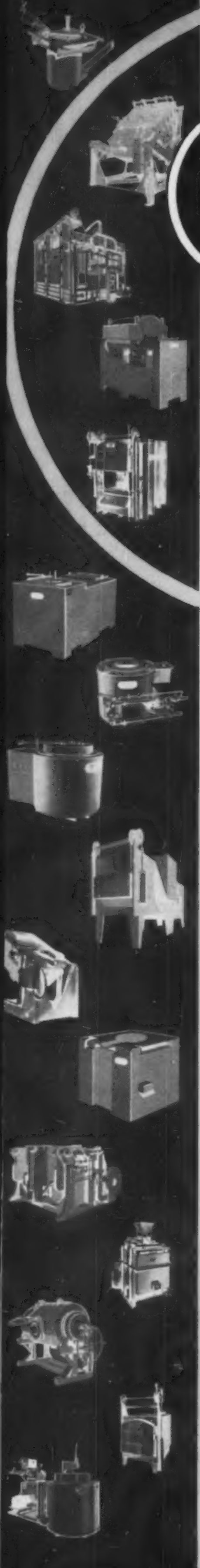
Mallory-Sharon Metals Corp. . . . Niles, Ohio, has been awarded a contract by the Air Materials Command, Wright-Patterson Air Force

Continued on page 134

Photograph courtesy of Soo Foundry, Sault St. Marie, Ontario







LINDBERG FISHER

This nameplate is on all the equipment anyone needs for melting and holding aluminum

Heat and aluminum have been Lindberg's babies for many years. If your product requires the application of heat to aluminum anywhere along the line, we can help you do the job. Lindberg-Fisher furnaces cover every requirement of "heat for aluminum" and embody the latest developments in the field. Many new design and engineering features make Lindberg-Fisher melting and holding furnaces, and accessories, the most modern equipment available to industry.

With Lindberg-Fisher furnaces too, you get the expert technical skills of Lindberg Engineering Company's staff of engineers, metallurgists, technicians, widely experienced in all phases of aluminum melting, casting and treating. Because Lindberg builds all kinds of melting equipment, gas—oil—electric (resistance, 60 cycle induction, arc, or high frequency) . . . we can intelligently and objectively recommend the proper type of furnace to suit your particular conditions and needs.

We can fit the latest melting and holding equipment into your production line efficiently and economically—helping you to manufacture your product to closer specifications, and at a lower cost. Consult your local Lindberg representative. You'll find him listed in the local classified telephone directories in major industrial areas.

Lindberg-Fisher Division, Lindberg Engineering Company, 2440 West Hubbard Street, Chicago 12, Illinois. Los Angeles plant, 11937 South Regentview Ave., at Downey, Calif. In Canada, EFCO-Lindberg, Ltd., Toronto. *Also factories in:* Argentina, Australia, England, France, Germany, Italy, Japan, Scotland, South Africa, Spain and Switzerland.

On the following two pages we've illustrated and described the Lindberg-Fisher equipment that covers all your "heat for aluminum" needs. Will you please turn the page?

LINDBERG heat for industry

Circle No. 201, Page 155-156

FROM THE VERY BEGINNING

Starting with alloyed ingot or molten metal delivery from the reduction cells, aluminum can be processed in a wide selection of furnaces.

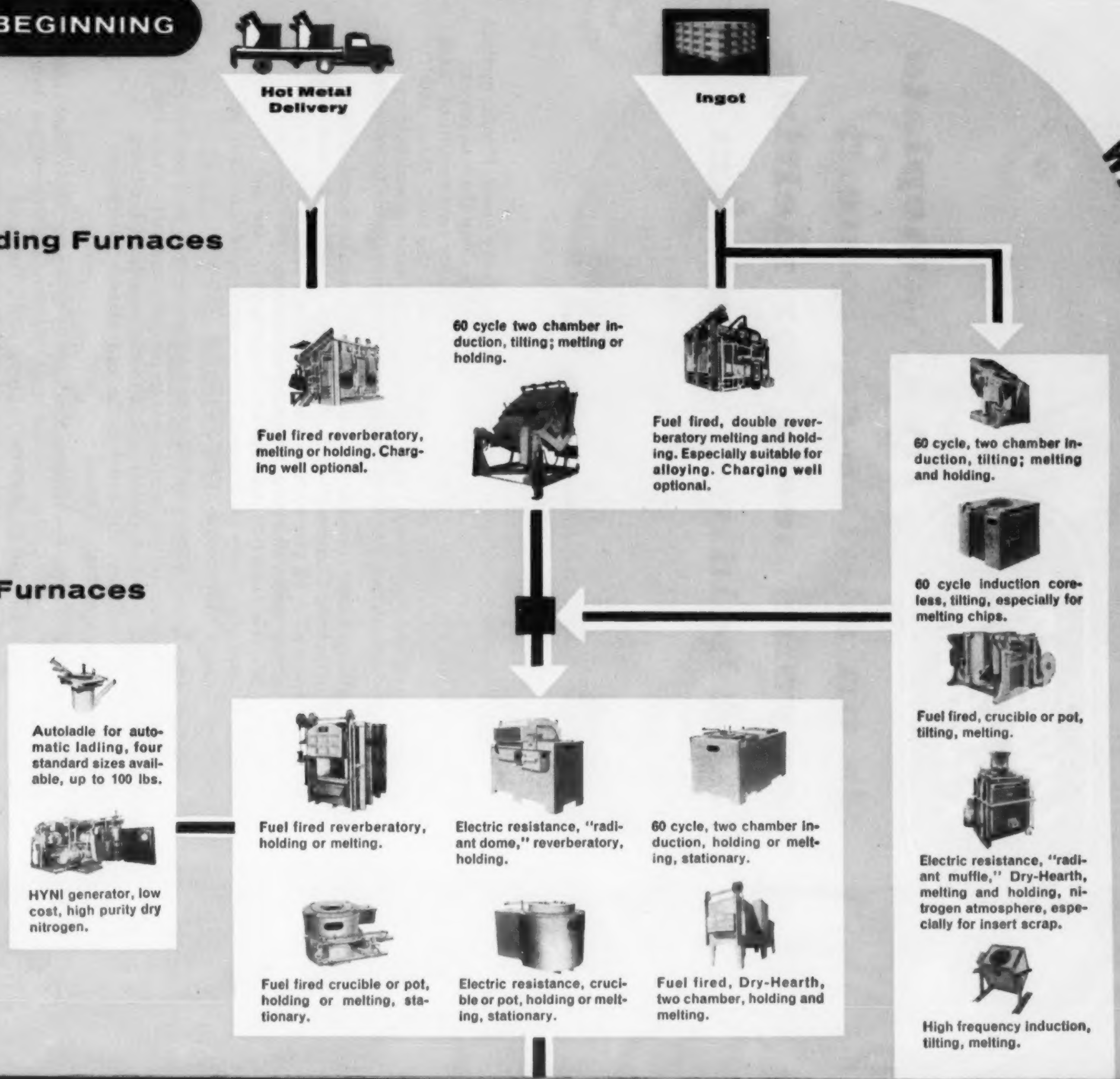
In Melting and Holding Furnaces

As shown in the flow diagram molten aluminum is delivered to either large capacity fuel fired reverberatory furnaces, or tilting two chamber induction furnaces for storage at suitable temperature . . . or alloyed ingot is melted and stored in similar furnaces . . . to provide an adequate supply of molten aluminum for the casting station area furnaces.

In Casting Station Furnaces

Molten metal received from the large storage or breakdown furnace described above or from smaller melting furnaces—again either fuel fired or electric, is received at the casting area, maintained at the correct temperature and processed into desired castings. Most of the holding furnaces illustrated can also be used for melting.

Many of the casting station furnaces shown can be equipped with the Lindberg-Fisher Autoladle for automatic ladling or hand ladling.



WHEREVER ALUMINUM NEEDS HEAT, LINDBERG-

FISHER EQUIPMENT WILL APPLY IT MOST EFFICIENTLY

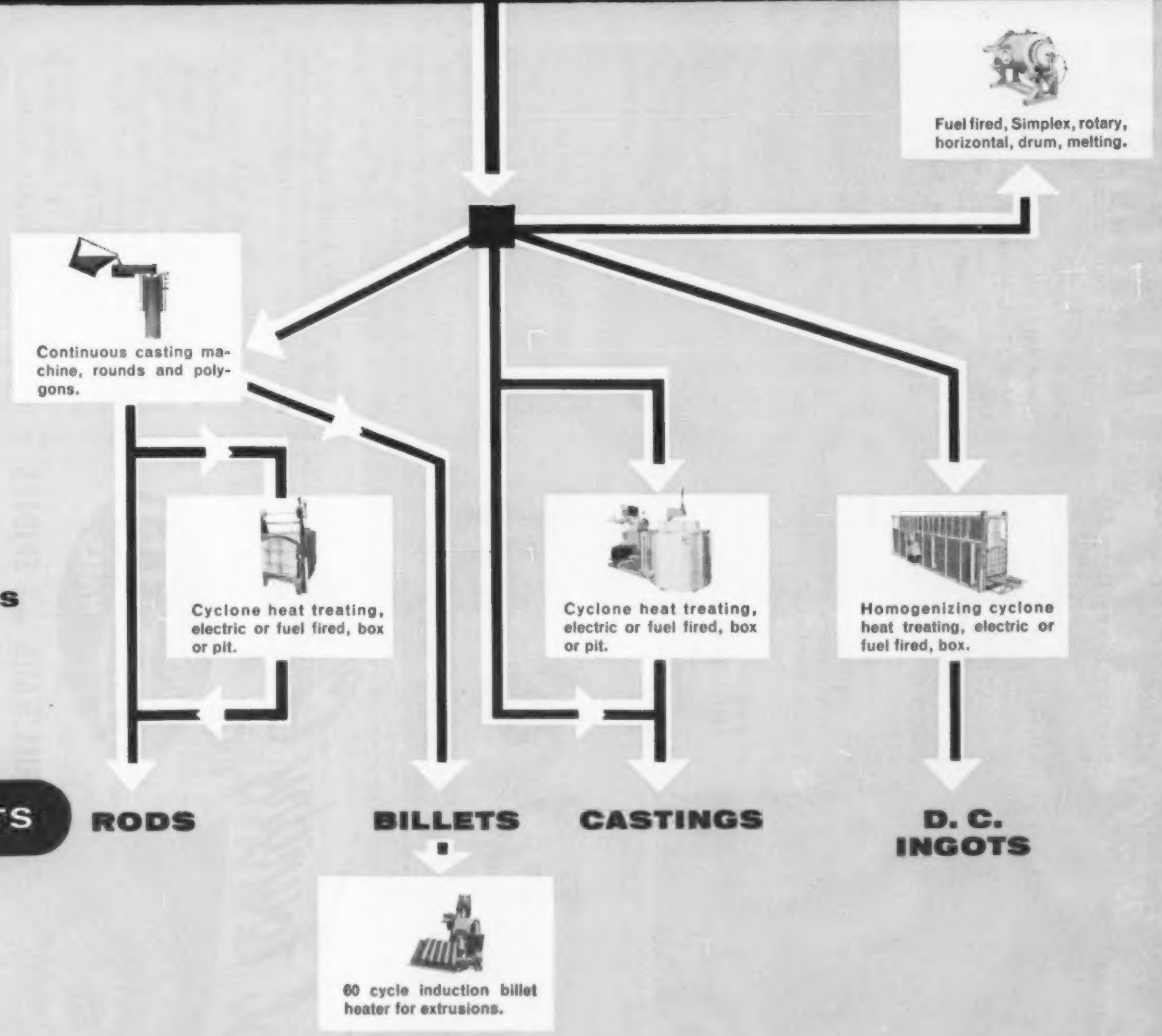
A unique innovation is the Lindberg HYNI Generator... which supplies dry, high purity nitrogen economically, as a protective atmosphere for both melting and holding applications.

In Remelting Furnaces

As the castings move out of the casting area for trimming, machining and finishing, the gates, risers, sprues, chips and scrap castings, etc., are returned to a remelt operation in one of the furnaces shown on the far right. These furnaces can be used for ingot meltings as well as for remelt operation.

In Heat Treating Furnaces

From the trimming and sorting station some castings are ready for direct use, others require suitable heat treatment as shown.



TO THE FINAL PRODUCTS

Lindberg can provide ANY furnace for your needs.

LINDBERG heat for industry

Circle No. 201, Page 155-156

foundry trade news

Continued from page 128

Base, Dayton, Ohio, to build a prototype cold mold crucible for induction melting.

Rolle Mfg. Co. . . . Lansdale, Pa., producer of aluminum and magnesium castings, has been acquired as a wholly owned subsidiary of DEK Industries, Inc., New York, manufacturer of aluminum products.

Canadian Steel Improvement, Ltd. . . . Toronto, will produce bonded aluminum and cast iron brake drums for all Canadian-built Buicks. These are said to eliminate braking fade-out and give 50 per cent more wear for brake linings. Canadian Steel has signed a licensing agreement with Al-Fin Div., Fairchild Engine & Airplane Corp., which developed and patented the process of bonding used in bi-metallic brake drums.

Cleveland Metal Abrasive Co. . . . Cleveland, Ohio, has broken ground for a $350,000 addition to its present plant. The new 16,000 sq ft structure will house an electric melting furnace producing 12,000 tons of finished steel per year, in addition to conveyors, furnaces, tanks, crushers and testing machines.

Trenite Foundry Corp. . . has closed its plant at Trenton, N. J. after more than 50 years of operation.

Foundry Equipment Ltd. . . has formed a new associate company, F. E. (South Africa) Ltd. with headquarters at Johannesburg. Foundry Equipment also has associate firms in North America, Australia and Spain.

Gorham Mfg. Co. . . . Electronics Div., Providence, R. I. has added a new investment casting facility as part of the current expansion program, for production of aluminum, magnesium and copper alloy castings.

Ductile Iron Pipe . . . production will triple this year and by 1961 will climb to 100,000 tons annually, according to D. J. Reese, director, Ductile Iron Div., International Nickel Co.

Dow Chemical Co. . . . Midland, Mich., has formed Dow Metal Products Co., replacing the Dow Magnesium Products department to fabricate and semi-fabricate magnesium, aluminum and other metals. Produc-

Continued on page 146

ELIMINATE CUPOLA BLOCK

Photos courtesy of John Deere Malleable Works, East Moline, Illinois

BEFORE . . . photo of cupola from charging door up . . . note anchors in position ready to receive lining. Cupola is 53' 3" high and designed to melt 200 tons per day.

AFTER . . . same view after Goose Lake Castables were "gunned-on" to a thickness of 12" in the charging zone and 2½" in the upper stack area. Lining dried rock hard in 24 hours.

"GUN-ON" CUPOLA LININGS WITH GOOSE LAKE CASTABLES

This new method of lining the charging zone and upper stack areas of a cupola provides important savings through lower installation costs, lower material costs, plus increased lining life. Goose Lake Castables, gunned directly onto the cupola shell, provide a joint-free, monolithic lining that is stronger and offers greater resistance to erosion than a lining of brick or block. Castable linings dry rock hard — ready for use in 24 hours. When used to patch over old block, repairs are simplified and waste eliminated.

The use of Goose Lake Refractory Castables to line your cupolas can save you thousands of dollars in time, labor and money each year.

Advantages:

- Cuts lining time 75%
- Reduces refractory costs 43%
- Provides a strong, erosion resistant, joint-free, monolithic lining for a longer service life
- Eliminates block inventory problems . . . just order your lining "By-the-Bag"
- Lining thickness may be varied to meet charging requirements
- Installs 75% faster than block
- Eliminates need for installation scaffolding
- Dries rock hard — ready for use in 24 hours

WRITE TODAY FOR COMPLETE INFORMATION ON THIS TIME AND COST SAVING METHOD OF LINING CUPOLAS.

ILLINOIS CLAY PRODUCTS CO.

Main Office—Barber Building, Joliet, Illinois
Sales Office—208 South LaSalle Street, Chicago 4, Illinois

OTHER PRODUCTS FOR FOUNDRY USE . . . GOOSE LAKE Fire Clay and Fire Brick . . . THERM-O-FLAKE Insulation . . . Silica CHEM-BRIX

Circle No. 178, Page 155-156

Build an idea-file for improvement and profit. The post-free cards *on the last page* will bring more information on these new . . .

products and processes

SHELL CORE BLOWER . . . will produce up to 120 cycles per hour. Core box may be rocked while investing or curing. Adjusting studs permit perfect parallelism between core box faces. Handles boxes up to 11 x 13 x 10 in. Foundry Dynamics, Div. of Maclodyne Corp.
For More Information, Circle No. 1, Page 155-156

WATERLESS MOLDING SAND . . . producing high-precision castings is possible with use of new sand binder. Dry binder is used with mix of 120 to 190 gfn sand, oil and a catalyst. Principal advantages are said to be reduction in gas on pour-off and use of finer sands, principal disadvantage is said to be higher initial cost of low clay content sand used. Archer-Daniels-Midland Co., Federal Foundry Supply Div.
For More Information, Circle No. 2, Page 155-156

SPRUE CUTTER . . . features seal at junction of post and cup. Adjustable to variety of cope heights. All parts replaceable. Meldau Foundry Tool Co.
For More Information, Circle No. 3, Page 155-156

CO_2 SHELL MOLDS . . . combines close-tolerance aspects of shell molding with time, labor and equipment saving features of CO_2 process. National Cylinder Gas Co.
For More Information, Circle No. 4, Page 155-156

EPOXY FOR 500 F . . . new epoxy resin has heat resistance up to operating temperature of 500 F. Material is said to retain elasticity at higher temperatures. Marblette Corp.
For More Information, Circle No. 5, Page 155-156

CORE WIRES . . . made of cord-like, resin-impregnated fiber glass break up during shakeout, eliminating resorting and reforming. Cord forms to any contour, will not deform and will not weld to casting. Archer-Daniels-Midland Co.
For More Information, Circle No. 6, Page 155-156

SHELL CORE BOXES . . . are available cast-to-size by Shaw Process. Ledges on boxes permit use of inexpensive clamps. Wisconsin Pattern Works.
For More Infomation, Circle No. 7, Page 155-156

PRECISION FORMING PROCESS . . . can reportedly produce up to 50,000 parts a day in almost all castable metals and alloys. Process is said to successfully combine basic advantages of investment casting with those of coining, cold forming, screw machine production, etc. Company also claims dimensional tolerances to plus or minus 0.001-in. per in. and superior surface finish. Casting Engineers Inc.
For More Information, Circle No. 8, Page 155-156

EPOXY GASKETS . . . designed for head of core blowing machines and for exterior periphery of core boxes; reportedly prevent sand from blowing out during coreblowing. Furnane Plastics, Inc.
For More Information, Circle No. 9, Page 155-156

RESIN BLENDER . . . is simple tool that lends precision and speed to task of blending pattern resins and hardeners. Plaster Supply House.
For More Information, Circle No. 10, Page 155-156

LIQUID ALUMINUM . . . can be cast without heat or pressure. Reportedly hardens within two hours after adding hardener. Castable and bonding material. Devcon Corp.
For More Information, Circle No. 11, Page 155-156

PLASTIC RUBBER . . . new material for pattern and core box manufacture or repair has been developed. Resists abrasion and erosion. Suitable for other foundry applications. Dike-O-Seal Inc.
For More Information, Circle No. 12, Page 155-156

NYLON CORE VENTS . . . are said to eliminate sand sticking, fit shape of box, outlast metal vents 3 to 1. Ronson Industries.
For More Information, Circle No. 13, Page 155-156

SILICONE MOLD RELEASE . . . and lubricant reportedly eliminates sticky and marked molds in shell molding operation. Para Products.
For More Information, Circle No. 14, Page 155-156

INVESTMENT PATTERNS . . . can be produced from new synthetic, wax-like pattern material. Manufacturer claims uniform quality and physical characteristics produce consistent results. Pattern Materials Div., J. I. Holcomb Mfg. Co.
For More Information, Circle No. 15, Page 155-156

HEAVY DUTY BELT SANDER . . . can be operated vertical or horizontal, release lever ejects worn belts in seconds. Duro Metal Products Co.
For More Information, Circle No. 16, Page 155-156

CUT RISERS . . . from large castings with this new horizontal metal cutting band saw with an 18 in. max length of cut. Operator dials variable speed drive in range of 60 to 300 ft per min to select optimum cutting speed for the job. W. F. Wells & Sons.
For More Information, Circle No. 17, Page 155-156

WATERPROOF AND INSULATE . . . cement, cinder block and metal buildings with new liquid metallic coating. Pace Products, Inc.
For More Information, Circle No. 18, Page 155-156

HYDRAULIC DUMPER . . . for dumping containers holding sand, castings, etc. Unit is mobile and can lift three tons up to four feet high for dumping. Essex Conveyors, Inc.
For More Information, Circle No. 19, Page 155-156

SURFACE PROTECTION COMPOUND . . . prevents scale formation during welding, heat treatment and stress relieving. Sticks to casting so blast from torch will not blow it away. Arcair Co.
For More Information, Circle No. 20, Page 155-156

HEAVY DUTY . . . vibrating feeder designed for the heaviest kind of foundry needs. Has capacity up to 1000 tons per hour. Deck styles include pan, tubular and spreader-type. Jeffrey Mfg .Co.
For More Information, Circle No. 21, Page 155-156

ELIMINATE METAL PENETRATION . . . with new high refractory using cold setting binder. May be used as rammed facing or for lining core boxes where heavy metal sections lead to penetration. G. E. Smith, Inc.
For More Information, Circle No. 22, Page 155-156

MOBILE SANDRAMMER . . . has a 15 ft reach and 24 in. head for ramming

a ton of sand per minute. F. E. (North America) Ltd.
For More Information, Circle No. 23, Page 155-156

WEIGHT-SHIFTER . . . automatically places mold weights and later removes weights from poured-off molds. Handles up to 400 molds per hour. Planet Corp.
For More Information, Circle No. 24, Page 155-156

ALUMINUM ALLOY . . . claiming unique mechanical characteristics is called "Adaptaloy." Properties include exceptionally high elongation, impact strength and malleability. Federated Metals Div., American Smelting and Refining Co.
For More Information, Circle No. 25, Page 155-156

AUTOMATIC BATCH CONTROL . . . for mixing mold and core sands. Said to afford the latest in proportioning control opportunities through automatic presetting of unlimited numbers of

Continued on page 138

products and processes

Continued from page 136

batch formulas. Can control as many as 20 different ingredients including moisture compensation. Toledo Scale Corp.
For More Information, Circle No. 26, Page 155-156

"FLIP-TOP" CAP . . . for thermocouple head assembly protects wires from corrosion, abrasion and mechanical damage. New ceramic block handles thermocouple wires from 8 gage down to smallest sizes. Simplifies servicing all your thermocouples around the plant. Pyrometer Co. of America, Inc.
For More Information, Circle No. 27, Page 155-156

PORTABLE SANDBLAST . . . for use with any tank-type air compressor weighs 12 lb, has 12-qt abrasive capacity. Malray Products, Inc.
For More Information, Circle No. 28, Page 155-156

SUPER-HARD ALUMINUM WELDING ALLOYS . . . for precision welded zones on aluminum castings provide a 250-Bhn Hardness retained at high temperatures. Suited to such automotive applications as piston ring grooves, brake drums, valve seats and sheaves where localized hardness, wear and heat resistance are desired. Aluminum Co. of America.
For More Information, Circle No. 29, Page 155-156

SELF-PROPELLED HYDRAULIC CRANE . . . extends boom horizontally 25 ft, swings through full circle and tilts upwards to 60 degrees. Operates in 10 ton range. Baldwin-Lima-Hamilton Corp.
For More Information, Circle No. 30, Page 155-156

USE SIMPLE CRAYONS . . . to determine metal temperatures as high as 2500 F. Learn about the 80 specific temperature ratings now available in Tempilstik crayons. Tempil Corp.
For More Information, Circle No. 31, Page 155-156

EXTERNAL VIBRATOR . . . for moving foundry materials in bins, hoppers, chutes, tables, jolters and screens. Said to have more power per pound, it will speed flow, break bridging and cut production time. Unit operates quietly and attaches easily. B. W. Elliot Mfg. Co.
For More Information, Circle No. 32, Page 155-156

VACUUMIZED POWER SWEEPER . . . picks up bottles, wood 2 x 4's, pieces of steel plate, metal turnings, dust, lint and paper over a 70-in. sweeping swath. Task Master Inc.
For More Information, Circle No. 33, Page 155-156

ELECTRIC CURRENT MISER . . . is said to save up to 50 per cent of battery power during industrial truck maneuvering operations. How does it work? Circle number below for description. The Yale & Towne Mfg. Co.
For More Information, Circle No. 34, Page 155-156

PREVENT RUST . . . with new compounds added to wet blasting abrasive slurry. Film left on castings prevents rust from air or moisture. Wheelabrator Corp.
For More Information, Circle No. 35, Page 155-156

RECLAMATION of Sand in Foundries

by R. L. McIlvaine
National Engineering Co.
Chicago, Ill.

Steel foundrymen look on sand reclamation as simply a process to remove dead bonding material and fines to put the sand in condition to use in facing mixes. Gray iron foundrymen, however, think of reclamation as being a complete scrubbing of the sand grain to put it in new sand condition so that it may be used for oil bonded cores.

FIRST STEP

• The reclamation process usually consists of a crushing and screening operation with separation of magnetic material before the sand proceeds to some form of a scrubber. After the scrubbing operation this sand is usually passed through some form of air separating device to remove the fine material which has been abraided from the sand grain.

MULLER SCRUBBING

• More than thirty years ago several steel foundries adopted the practice of scrubbing dry sand from the shakeout in a muller type mixer. Then it was passed over a series of screens to remove the fine material and to divide the sand grains into the proper grain fineness classification. Some of these systems are still in use today and are producing sands that are entirely satisfactory for use in facing.

DRY SCRUBBING

• In 1950 a dry scrubbing apparatus was developed which entrained sand in an air stream and blasted it against a baffle.

THE COST

• The screening and classifying equipment together with the necessary conveyors comprise a considerable part of the total investment, and the degree of return on the investment is largely dependent on the degree of labor saving made possible by the handling equipment. The cost of the scrubbing operation itself usually is not more than 60 cents to $1.00 per ton, including labor, power and maintenance. However, as the amount of sand to be recovered per hour is usually small, any excess labor in handling or supervision runs the cost per ton up very fast.

SEGREGATION

• In sand reclamation by the dry scrubbing method we are dealing with sands which are very dry and flowable. Such sand is particularly susceptible to segregation. So every precaution should be taken to guard against segregation in the storage bin before the scrubber and in subsequent storing and conveying.

This article contains highlights excerpted from a talk presented at the 1959 AFS California Regional Foundry Conference.

Water Cooled Cupolas

by Harold Schwengel
Modern Equipment Co.
Port Washington, Wis.

At last the cupola, which has defied changes for so many years, has a new look—the water-cooled look.

Essentially, the water cooled cupola is still a vertical, cylindrical shaft in which raw materials are charged through the side or top and molten iron withdrawn from the bottom. The major differences, however, are:

- The absence of refractory in the melting zone.
- The use of carbon in the well.
- External application of cooling water.
- Protruding water cooled tuyeres.

This construction and the type of refractory used makes it a neutral melting vessel that can be operated with a basic, acidic, or neutral slag according to the flux materials charged at the charging door.

The three major advantages of the water cooled cupola are:

1. Flexibility and control of the melting processes
2. Prolonged periods of melting operation
3. Decreased costs for refractory and maintenance

Flexibility is obtained through the use of either a basic, acidic, or neutral slag. This is possible because the cupola is a neutral melting vessel by virtue of the fact that the melting zone is unlined and the well has a neutral carbon block. The controlled slag makes possible the substitution of cheap raw materials.

During the course of a single melting period it is possible to vary drastically the slag analysis and thereby produce consecutively different kinds of iron. High carbon, low sulphur, base irons for nodular can be obtained with a high basic slag; regular gray iron with an acid, neutral or low basic slag.

Control is obtained because the uncontrollable influence of refractory-lining contamination has been eliminated. In this way the resultant slag is obtained primarily through the materials as charged. This enables a fixed slag analysis to be maintained and contributes to a more uniform metal chemistry. Further control is possible because the water cooled shell remains uniform during the entire course of the heat. Maintenance

Water Cooled Cupolas

(Continued)

of equilibrium exists within the cupola and more even temperature and better metallurgical control results.

Although prolonged melting is not of major importance to the small tonnage foundries, it is the foremost consideration to many operators who encounter longer melting periods. With a water cooled cupola it is possible to hold the bottom up over night by banking the coke. This presents opportunity for holding the stack for periods ranging from a few days up to several weeks.

In cases where the bottom is dropped daily due to local economies involved, it is still possible to operate the same cupola on successive days rather than alternate days. This is due to the fact that after the bottom has been dropped, the cupola can be cooled rapidly. There are three lining areas in the water cooled cupolas, namely:

1) The front slag spout,
2) The cupola well and
3) The cupola stack

The upper stack has an acid lining. Being the same as a conventional cupola it requires the same amount of repair. The front slag spout refractory is a neutral or basic material. The amount of erosion depends upon the tonnage melted and the slag used. The cupola well is lined with carbon block which is a neutral material. Some of these wells have given a life of 125,000 tons.

The great saving, of course, is due to the fact that there is no lining at all in the melting zone. The entire area from a point one ft below the tuyeres to 11 ft above the tuyeres is a bare shell, water cooled on the outside.

Editor's Note: This article contains highlights excerpted from a talk presented at the 1959 Wisconsin Regional Foundry Conference and the 1959 California Regional Foundry Conference.

Butterfingers!

product report ...

Forest City Foundries Co., Cleveland, has solved its problem of removing reinforcing core wires from hollow castings. Instead of tedious tugging on core wires with pliers, they now insert one end of wire in a slot cut into an adapter extending from a rotary air tool made by Ingersoll-Rand Co. When power is applied the wire is quickly coiled

around the adapter and pulled from the casting. When core wires are burned to the casting this power technique is considerable faster than hand plyers and muscle. Picture shows a core wire coiled around the slotted adapter and the casting from which it was just removed.

For More Information, Circle No. 237, Page 155-156

$2000 to $3000 per minute was the expense of air and gas hose maintenance effecting a final assembly line in a large automobile foundry. Many valuable man-hours were saved by using O-shaped metal clamps on almost all air, gas, water and pneumatic material-moving hoses. Previous to using Circle Clamps, manufactured by Circle Clamp Corp., New York, a great deal of time was lost just traveling back and forth from the maintenance shop to the machine.

When an air, water or gas line failed it was necessary to shut down the equipment; disconnect the hose; measure the distance between the connections; take the hose back to the shop; cut the end; insert the coupling; clamp with a special tool; return the hose to the machine and re-assemble.

Now, this travel time is saved. The maintenance man cuts off the broken end of hose, reinserts the coupling, installs the Circle Clamp with pincers right out of the equipment box and reconnects the hose.

For More Information, Circle No. 238, Page 155-156

foundry trade news

Continued from page 134

tion since 1915 has been devoted almost exclusively to magnesium.

Aluminum Scrap . . . recovery by foundries and other aluminum users will total more than 900 million lb in 1959 with an annual salvage rate of 1-½ billion lb by 1965, it is predicted by the Aluminum Smelters Research Institute, Chicago.

General Railway Signal Co. . . . Foundry Div., Rochester, N. Y., is expanding its steel and iron castings capacity by approximately 40 per cent. About $800,000 has been spent in nine months for equipment expansion and modernization.

Reynolds Aluminum Co. . . . Cap de la Madleine, Quebec, is remodeling its foundry. New furnaces and a new type of continuous casting process machine are being installed for the foil business.

Westover Corp. & Associates . . . Milwaukee, is adding special service associates to its force. Services of retired experts in various fields are made available to industry on a short term basis. Companies using their services pay a fee rather than placing the expert on their payroll, eliminating many problems associated with taxes, pensions plans and fringe benefits. Says C. E. Westover, president, "The idea is not simply another plan to supply extra help. Neither is it simply a scheme for providing employment to people who have reached retirement age. Instead, this is an endeavor to tap the invaluable experience which is being wasted."

National Metallurgical Laboratory . . . Jamshedpur, India, will sponsor a symposium on "Pilot Plants in Metallurgical Research and Development," in February, 1960 at Jamshedpur. Invitations have been extended to engineers, technologists, metallurgists and research scientists in India and abroad to attend and contribute technical papers for discussion.

Glamorgan Pipe & Foundry Co. . . . Lynchburg, Va., has created a plastics division to manufacture and sell rigid polyvinyl chloride pipe. This marks the entrance of Glamorgan into the plastic pipe field.

Dalton Foundries, Inc. . . . Warsaw, Ind., has acquired Endicott Church Furniture Co. as part of its expansion program. Dalton will also expand its gray iron facilities and the company also plans to enter the permanent mold castings field.

Precision Castparts Corp. . . . Portland, Ore., has added new vacuum melting facilities to their investment castings plant for the production by the vacuum remelting process.

McCormick Steel Co. . . . Houston, Texas, has been appointed a distributor for Olin Mathieson Chemical Corp., aluminum alloy, pig and ingot in Texas, Louisiana, New Mexico, Oklahoma, Kansas and parts of Ar-

Aluminum Permanent Mold . . . casting production use in civilian vehicles accounted for 64.1 per cent of shipments for the last half of 1958; an increase of 6.2 per cent over first half figures. Industrial and commercial machines, equipment and tools remained as largest users of aluminum sand castings with 42.1 per cent of shipments.

Eutectic Welding Alloys Corp. . . . Flushing, N. Y., is building a new foundry and expanded metallurgical division adjoining its St. Sulpice, Switzerland, facilities.

here's . .

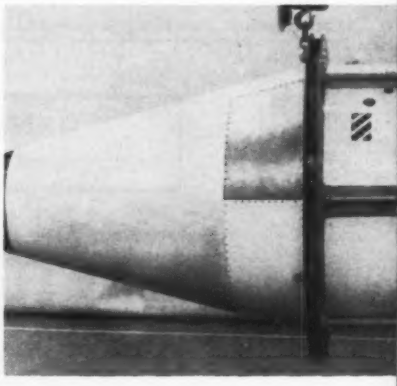
. . . **Aply-Tec,** New York, uses an aluminum die casting to produce a cool smoking, low priced pipe. The stem is cast with twin cooling shafts running the length of the smoke channel.

Also cast into the stem is a device which permits regulation of the draft of the bowl. The stems require only vacuum deposited coatings of aluminum, gold, silver or metallic pastels to prepare them for assembly with briar bowls, rubber mouth-pieces.

. . . **Solon Foundry,** Solon, Ohio, has installed a hand-cranked rotating de-

vice to help core sand flow into core blower. Sand sticking in the storage hopper is now a myth.

. . . **The Dow Chemical Co.,** Midland, Mich., contributed to the success of the Discoverer satellites which contain more than 600 lb of magnesium-thorium alloys. A part of this weight comprises many magnesium-

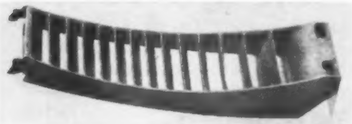


. . how

. . . **Crouse-Hinds Co.,** Syracuse, N. Y., built safety into mold squeezing operation. Safety switch makes squeeze operation possible only when both hands are on controls. Left hand

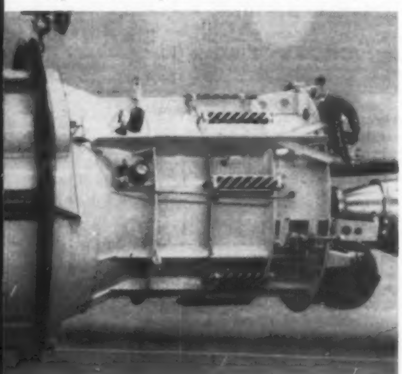
must first push in valve controlling small, single-acting air cylinder which locks the squeeze mechanism. Then the right hand pulls down lever which releases lock and activates squeeze-head action.

. . . **Ferro Cast Div., J. B. Rea Co.,** Santa Monica, Calif., designed a cast part for the thrust reverser on the Boeing 707 jet airliner. This "cascade"



is 19 in. long, has side wall 0.078 in. thick and vane thickness as low as 0.056 in. This large investment casting replaced a weldment.

thorium (HK31A-T6) castings. The alloy was selected by Lockheed Aircraft Corp. for its ability to withstand high aerodynamic heating and wide temperature variations. Dow says the alloy is serviceable to 900 F.



classified advertising

For Sale, Help Wanted, Personals, Engineering Service, etc., set solid . . 25c per word, 30 words ($7.50) minimum, prepaid.
Positions Wanted . . 10c per word, 30 words ($3.00) minimum, prepaid. Box number, care of **Modern Castings,** counts as 10 additional words.
Display Classified . . Based on per-column width, per inch . . 1-time, $18.00 6-time, $16.50 per insertion; 12-time, $15.00 per insertion; prepaid.

HELP WANTED

NEW SERVICE

MODERN CASTINGS announces a new service available to all members of the American Foundrymen's Society. Any member seeking employment in the metal-castings business may place one classified ad of 40 words in the "Positions Wanted" column, FREE OF CHARGE. Inquiries will be kept confidential if requested. Ads may be repeated in following issues at regular classified rates. Send ads to MODERN CASTINGS, Classified Advertising Dept., Golf and Wolf Rds, Des Plaines, Ill.

The company is a large investment casting foundry located in the East. We are casting parts in excess of ten pounds and need a man experienced in the gating and risering of parts of this size. Induction melting experience would also be desirable.
Excellent working conditions and fringe benefits with opportunity for continued advancement. Salary commensurate with ability. **Box H-101, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

PLANT ENGINEERS

Experienced on layout of all types of foundry equipment, material handling and material flows. Send complete details on work history, education and family status. Include recent photograph. All replies confidential. **Box F-140, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

WANTED:

Top flight foundry molding foreman for heavy machinery jobbing, gray iron and ductile iron foundry.

The Colonial Foundry Co.
Louisville, Ohio
William Love, President

FOUNDRY SUPERINTENDENT

Should have experience in achieving modern production standards with up to date mechanized foundry equipment.
This man will be responsible for all melting and molding operations in doing jobbing work in a production basis. Position entails supervision of foremen and production personnel with no responsibility for core or cleaning departments.
A good opportunity with a well-established company in Central New York.

OBERDORFER FOUNDRIES, INC.
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Attention – Personnel Director

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when you need SUPERVISORY or TECHNICAL men why not consult a man with actual foundry experience plus 15 years in finding and placing FOUNDRY PERSONNEL.
Or if you are a FOUNDRYMAN looking for a new position you will want the advantages of this experience and close contact with employers throughout the country.

For action contact: John Cope
DRAKE PERSONNEL, INC.
29 E. Madison St. Chicago 2, Illinois
Financial 6-8700

METALLURGIST SUPERVISOR

Small plant in Ohio seeking college graduate, with experience in nonferrous, small casting foundry operations. Desire person with supervisory experience to handle complete foundry operations. Please send resume of education, experience and salary requirements. Reply to **Box No. G-116, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

MANUFACTURERS' REPRESENTATIVE
Foundry Industry

Large nationally known corporation expanding marketing activity in foundry field. Product 100% replaceable with high repeat sales. Seeking aggressive foundry supply houses as exclusive distributors or successful manufacturers' representatives selling to foundry industry. Key territories open due to national expansion. All replies treated confidentially. **Box H-100, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

METALLURGIST preferably graduate with experience in Ceramic molding, Shaw or Unicast process, casting low and high alloy steel.

This is a new position – salary open. Send resume and approximate salary to **A. H. Thompson, Personnel Director – Pratt & Letchworth Division, 189 Tonawanda Street, Buffalo 7, New York.**

GENERAL FOUNDRY FOREMAN

Thoroughly versed in green sand molding and production procedures, pouring, gating and risering and scrap reduction. Must be able to get along well with people. Excellent salary along with company paid benefits– good opportunity for a qualified man. Mechanized malleable iron foundry located in Midwest. Enclose resumé, references, experience, etc. **Address Box G-103, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

INDUSTRIAL ENGINEER

Experienced in foundry operations as well as general industry. Capable of taking over management of industrial engineering division of ACME member consulting firm. Degree necessary. Age 35-45. Send complete details and include recent photograph All replies held in confidence. **Box F-135, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

METALLURGIST required by progressive and expanding company manufacturing specialized chemical products for the foundry industry. Applicants should preferably be under 35, possess a metallurgical degree, and have had several years experience in foundry work; thorough knowledge of casting defects, metallography and photography is essential. The successful applicant will be employed in the Technical Service Laboratory. The position offers excellent prospects of advancement and good starting salaries will be paid. Applicants should submit a resume of qualifications to:

FOUNDRY SERVICES, INC.
P. O. BOX 8728
CLEVELAND 35, OHIO

PLANT SUPERINTENDENT

Small plant in Ohio seeking superintendent of operations and maintenance involving non-ferrous castings, machining, finishing and assembly operations. Desire person with metallurgical and foundry background in non-ferrous castings. Please send complete resume of education, experience and salary requirements. Reply to **Box No. G-115, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

Help Wanted

SALES METALLURGIST

Challenging opportunity to develop sales of heat and corrosion resistant castings produced in new high alloy division. Metallurgical degree and customer contact experience essential. Finest living and recreational advantages.
Send complete resume, including salary requirements, and photo if possible, to:

W. E. Niemackl
MINNEAPOLIS ELECTRIC STEEL CASTINGS COMPANY
3800 N.E. Fifth Street
Minneapolis 21, Minnesota

METALLURGIST

Progressive young aluminum and brass foundry in the east desires the services of metallurgist, familiar with sand and permanent mold foundry operations, run analysis and assist foundry manager. Send complete resume and advise salary expected.

Box H-104, MODERN CASTINGS
Golf and Wolf Roads, Des Plaines, Ill.

GRADUATE ENGINEER

35-40. Must be capable of supervising establishment of Process Engineering Department in grey iron foundry, including methods, rigging, standards for estimating, scheduling, budget and cost control. Professional experience desirable but not necessary. Give complete experience and compensation requirements with photo. **Box H-105, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

COMPTROLLER

35-45. Must have substantial background in foundry cost control and budgets. Professional experience desirable but not necessary. Send complete record and compensation requirements including recent photo. **Box H-106, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

Engineering Services

FOUNDRY CONSULTANT—NON-FERROUS
Sand Casting — permanent mold casting — centrifugal casting — in aluminum — brasses — bronzes — 30% leaded bronze — aircraft quality bearings and castings —
ED JENKINS, 286 PENOBSCOT BLDG.
DETROIT, MICHIGAN — PHONE:
WOODWARD — 5-7947

SALES REPRESENTATIVE — New York Importer, part of international organization enjoying exclusive representation top British manufacturers foundry and engineering equipment seeks sales representative possessing technical knowledge foundry equipment, successful sales experience, initiative, and organizing ability. Send full details age, education, experience, marital status, salary required. All details held in strictest confidence. Please reply to: **Box H-102, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

Positions Wanted

FOUNDRY EXECUTIVE. Progressive foundryman with 16 years experience as foundry superintendent, finishing superintendent and industrial engineer in both malleable and steel would like to make change. Consider sales, operating or consulting. Prefer small plant. **Box G-107, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

SUPERINTENDENT-MANAGER 47 year old superintendent and manager of ferrous and nonferrous production and jobbing foundries. Practical, technical and sales background. 20 years supervisory experience. Good trouble shooter. Best of labor relations. **Address Box H-103, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

Wanted to Buy

BACK VOLUMES — Wanted to buy for cash of foundrymen, TRANSACTIONS American Foundrymen's Society and other scientific technical Journals, **A. S. ASHLEY 27 E. 21, N. Y. 10, N. Y.**

WANTED! BOUND VOLUMES OF TRANSACTIONS OF AFS. Arrangements to sell bound volumes of TRANSACTIONS of AFS, intact and in good condition, may be made through AFS Headquarters. Those who have no further use for any volumes of TRANSACTIONS on their bookshelves are requested to communicate with the **Book Department, American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Illinois.**

For Sale

(3) CORE TRUCKS — Used C.M.D. Pneumatic. 27" W. x 16" L. Cap. 600#. Excellent condition. New price $235 — Our price $100. each.

PASSMAN BROS.
1101 W. Lake St., Chicago 7 MO-6960

Detroit Rocking Indirect Arc Electric Furnace Type LFC, 125 KW, Capacity 350 lbs. cold scrap, 500 lbs of molten metal. Two shells, complete with automatic electrode control, main control panel and power transformers for 12,000 volt primary power supply. All equipment used very little and in excellent condition. Immediately available. Make offer to: **Box G-111, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOR SALE

Pangborn #2 Type GD-1 Barrell Air Blast Machine. Used, but in excellent condition. Bargain. Write us for complete details and picture.

WESTERN FOUNDRY COMPANY
Post Office Box 6313
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FOUNDRY FOR SALE, only job shop in rapidly growing Colorado Springs area. Complete ready to operate 75 ton-per-month capacity. Patterns, flasks and equipment. Total price $15,000 with one-third down—owner will finance balance at 5% with two year payout to qualified buyer. Long term lease at $150.00 per month on a 40x80 building with crane.

ROCKY MOUNTAIN FOUNDRY
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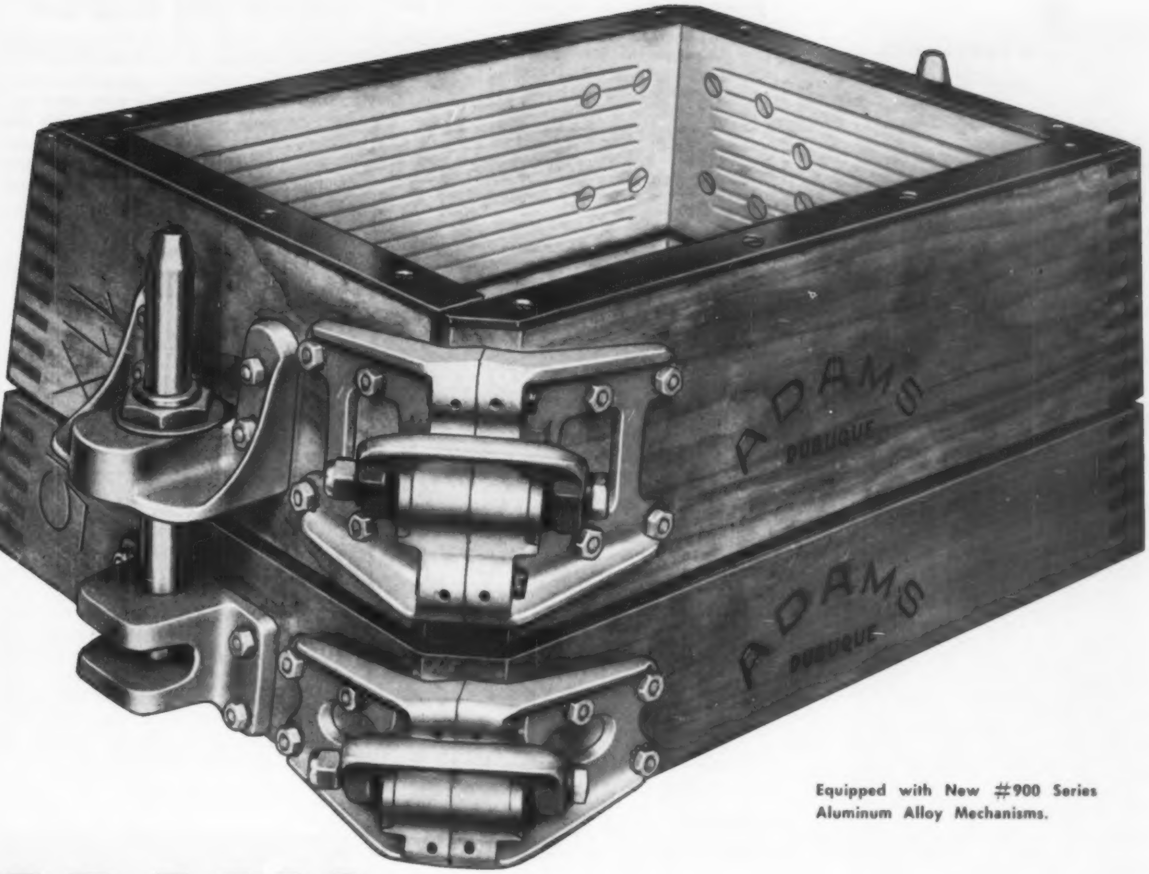
Colorado Springs, Colorado

SPECIAL SERVICE . . . You may have a **problem** which you have been **unable to resolve** with your own organization personnel. A problem that could be **quickly solved** in a month . . . a week . . . a day . . . **by a well-qualified** man of experience. **We have** a man or men with many years of experience in the exact areas with which you are concerned. Representative areas include plant layout, modernization, operation, selection and installation of equipment, technical processes, metallurgy, personnel development methods, etc. To help you, we assign individuals who have 40 or more years of actual experience in specialized fields . . . invaluable know-how, yours to command for as long as you need it. **Write or phone** for detailed information.

WESTOVER SPECIAL SERVICE ASSOCIATES
3110 W. Fond du Lac Ave., Milwaukee 10, Wisconsin, Phone – Custer 3-2121



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CHERRY EASY-OFF FLASKS are of proven design and construction.
CHERRY LUMBER is the finest available, carefully selected and thoroughly air dried.

SIDES AND ENDS finished 1⅛" on all standard size flasks. 1¼" and heavier on flasks of larger perimeters and greater depths.

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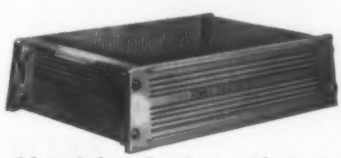

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Circle No. 195, Page 155-156

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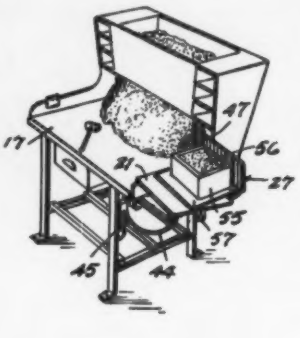
Patented Core Draw Unit

■ Some benefits of mechanization have been applied to bench coremaking operations by a patent for a core draw apparatus. This unit is clamped to the coremaker's bench so that he can conveniently place the core box (55) against the unit's vibration panel (27) with one end of the box held against the stop (47). By pressing the knee-operated valve (45), the panel vibrates the box to loosen the core, enabling the coremaker to draw the core by lifting the box along the vibrating panel. *Pat. No. 2,851,749, Peter S. Hardy, assignor to Peerless Aluminum Foundry Co.*



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8	20	32	44	56	68	80	92	104	116	128	140	152	164	176	188	200	212	224	236
9	21	33	45	57	69	81	93	105	117	129	141	153	165	177	189	201	213	225	237
10	22	34	46	58	70	82	94	106	118	130	142	154	166	178	190	202	214	226	238
11	23	35	47	59	71	83	95	107	119	131	143	155	167	179	191	203	215	227	239
12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240

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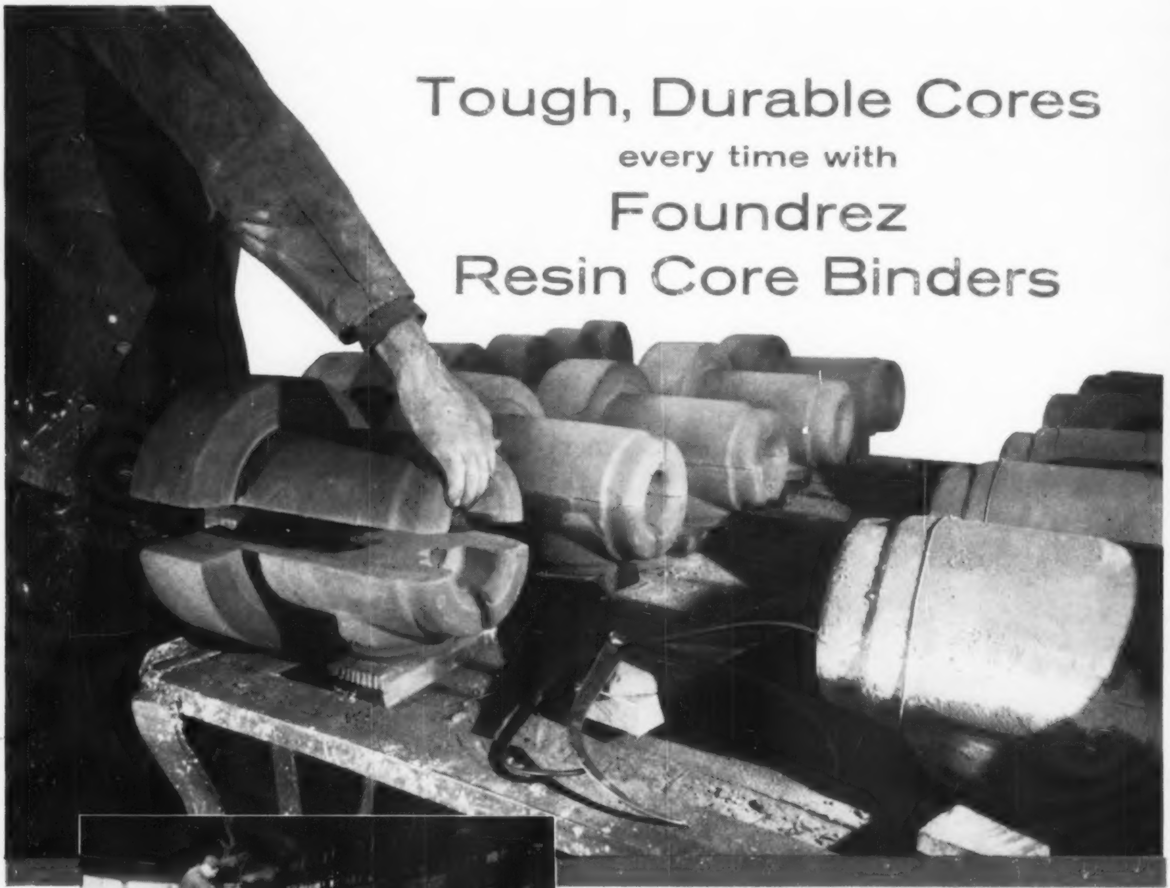

Photos taken at Florence Pipe Foundry & Machine Co., Florence, N. J.

Volume production of heavy castings demands that the córes used by Florence Pipe Foundry & Machine Company stand up under rough handling. Florence secures the high tensile strength and hardness needed in these cores by using RCI FOUNDREZ 7100 series resin binders in their molding sand.

These water dispersible phenol-formaldehyde core binders are especially formulated for use where baking time is at a premium. In addition they possess higher hot strength and slower collapsibility than either core oils or urea-formaldehyde binders.

These resins are used in conventional core sand mixtures containing cereal binders and water. Only half as much FOUNDREZ as regular core oil is required to produce equivalent core handleability. Reichhold's FOUNDREZ 7100 series includes:

Foundrez 7101 — a high solids binder compounded for foundries where core gas is a problem. Extremely effective in producing cores with high strength and hardness.

Foundrez 7102 — formulated for very rapid baking schedules, this binder provides excellent green strength with a minimum of cereal binder.

Foundrez 7103 — features easy collapsibility and a low viscosity which permits ready mixing.

Foundrez 7104 — combines a high degree of stability with high tensile strength. Resultant cores are extremely moisture resistant — may be stored for long periods without fear of moisture pickup.

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